



## Appendix B. Issue Papers

# MoveAZ Plan

*prepared for*

**Arizona Department of Transportation**

*prepared by*

**Cambridge Systematics, Inc.**

*In association with*

**Lima & Associates**

August 2004



*MoveAZ Plan*

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*prepared by*

Cambridge Systematics, Inc.  
555 12<sup>th</sup> Street, Suite 1600  
Oakland, California 94607

*August 2004*

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# **Impacts of Global Economic Trends on Transportation in Arizona**

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# Impacts of Global Economic Trends on Transportation in Arizona

## ■ Executive Summary

This paper discusses the major domestic and global trade and economic trends that will affect Arizona's transportation system, and provides general guidance for Arizona's future transportation investments. While the State's economy, and thus its transportation system, has historically been geared toward mining and agriculture, changes in world trade patterns and the increasing dominance of the service economy have presented new opportunities for Arizona.

Global economic expansion and liberalization of world trade has opened up new import and export markets for the United States and for Arizona. Businesses have taken advantage of cheaper labor and materials in foreign markets, moving production facilities, and now even customer service centers and other back-room operations, across borders and overseas. The *maquiladora* industry in Northern Mexico is just one manifestation of globalization in manufacturing. Improved communications capabilities have allowed companies to establish global supply chains, which in turn has led to the consolidation and internationalization of freight shipping firms.

"Pull" logistics structures, which rely on information about customer demand and availability of supplies, have revolutionized the manufacturing process. Remnants of "push" logistics, like stockpiles of excess supplies and warehouses full of finished goods, have been replaced with just-in-time delivery and made-to-order manufacturing. Pull logistics increases the importance of less-than-truckload (LTL) and small parcel deliveries, which has translated to an increase in delivery trucks on already congested metropolitan freeways and arterials. While bulk delivery of certain raw materials and supplies will continue to be handled by rail, the fastest-growing segment of freight shipments will be handled by services like FedEx and UPS, and by other shippers that can adapt to the changing needs of their clients. As high-value, time-sensitive shipments increase in volume, air cargo is increasing in importance. In addition to providing adequate ground transportation to accommodate an increase in LTL and small parcel deliveries, Arizona will have to ensure that adequate air cargo capacity is provided at airports around the State.

Much of the improvement in productivity that led the world's and Arizona's economic expansion was made possible by advances in information and communications technology. Information technology has improved the efficiency commercial vehicle operations in the private sector, but public sector applications of IT can improve the operations of the entire transportation system. Improving travel time reliability by preclearing commercial vehicles at Arizona's ports of entry, providing real-time traffic and travel time information to commuters so they can make better route, mode, and departure time choices, and

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reducing paperwork for freight shipping firms by allowing them to file information electronically are just three tangible ways that information technology can improve productivity in Arizona. Other IT applications such as Smart Cards encoded with electronic manifests and biometric information about drivers can be used to improve safety and security of transportation in Arizona.

Deregulation in the transportation industry has increased competition and profitability in some parts of the industry, but overconsolidation in other sectors may have reduced competition. The air industry was profitable before 9/11, but with ever increasing security regulations it is not certain how the industry will respond in the long term. Arizona is heavily dependant on the continued viability of America West airlines, which provides three quarters of the passenger service to Phoenix. The State should work to expand the availability of domestic and international nonstop flights from Phoenix to increase the attractiveness of Phoenix for corporate offices. Air cargo also will benefit from increased nonstop service, especially flights to Asia, Europe, and Latin America.

U.S. trade with Asian and European nations has dominated U.S. foreign trade since World War II and will continue to grow. Well-established east-west trade flows across the United States include vital links running across the state of Arizona. The increasing dominance of the Ports of Los Angeles and Long Beach will generate and increase in demand for trans-Arizona freight shipments. Interstates 10 and 40 and two main rail trunk lines cross the State from east to west, and are important to the U.S. economy and Arizona's economy. The State must maintain the flow of freight and passengers along these important arteries so that goods from U.S. ports and Arizona's factories and farms can reach their destinations without costly delays. Urban congestion in Arizona is worsened by through traffic. Freight shipments should be able to pass through metropolitan areas unimpeded, but to the greatest extent possible their interference with intraurban passenger and freight travel should be minimized.

Mexico and Latin America are relative newcomers to the global marketplace, but they promise to lead the rest of the world in growth over the next two decades, and Latin America will be Arizona's top export market for the foreseeable future. An increase in trade with Mexico will put pressure on north-south trade routes and, in particular, U.S.-Mexico border crossings. The maquiladora industry in particular has generated demand for truck shipments, rail shipments, air cargo shipments, and commuter trips many of which require a border crossing and the use of roads, rail lines, and airports within Arizona. Recent initiatives by U.S. and Mexican authorities have eased the flow of commercial and passenger vehicles across the border, and Arizona has contributed to congestion relief through agricultural preinspection programs and other initiatives. As advances in inspection and information technologies become available, Arizona should work with U.S. and Mexican authorities to reduce delays for incoming and outgoing vehicles.

The changes brought about by the rise of the service economy have influenced the way Arizonans work, play, live, and travel. Population growth and increases in regional freight traffic will require continued expansion of metropolitan highway networks. Arizona's decisions about transportation investments should be made in tandem with land use decisions. Multimodal improvements to the transportation system can be used

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as a tool to influence future development patterns, providing Arizonans a variety of alternatives for living, working, and traveling. Housing affordability and environmental conservation are just two issues that can be undertaken as part of the long-range transportation and land use planning process.

## ■ 1.0 Introduction

For the Native Americans living centuries ago in what is now called Arizona, transportation was as important to the civilization's culture and economy as it is to present day Arizonans. While concepts of "foreign" and "world" are much different today than in pre-Columbian times, transportation still provides the link between communities that facilitates trade and communication. Instead of the ancient trade trails used by Native Americans and, later, by newcomers from the East, airports, railroads, and interstate highways now link Arizona to trade centers. Historically, the State's economy has depended on "the Five Cs" – Copper, Cattle, Cotton, Citrus, and Climate – but in the last half-century one "S" has begun to dominate: Services. Similar economic shifts have occurred throughout the United States, as the exchange of information has overtaken manufacturing and agriculture as the industry leading the nation and Arizona's, economic expansion.

Economic expansion also is taking place around the world due to the liberalization of global trade policies. The United States and other countries have formed multi-national trade agreements with major trading partners in order to facilitate the movement of goods and information across borders. In response, corporations have established global supply chains that allow for more efficient uses of resources and personnel.

Technological advances in freight transportation have allowed for the growth in productivity that has accommodated much of the recent expansion in international trade. However, all elements of the transportation system in Arizona and the United States, from seaports to highways to the air system, are quickly approaching their physical capacity limits. Unless transportation system capacity expansions keep pace with economic expansions, transportation will become a constraint for growth rather than a facilitator of growth.

With two transcontinental interstate highways, two east-west trunk rail lines, a large hub airport, a major border crossing, and the future north-south CANAMEX trade corridor as key components of its transportation system, Arizona has the opportunity to profit from the changing global economy and the accompanying changes in the ways people and goods are moved. Rather than reacting to inevitable growth in travel demand on Arizona's highways, railroads, transit systems, and at its airports, Arizona should take proactive steps that achieve the maximum economic benefit in anticipation of economic changes.

This paper discusses the major domestic and global trade and economic trends that will affect Arizona's transportation system, and provides general guidance for Arizona's future transportation investments. The paper is divided into three sections. The first section deals with liberalization of foreign trade and how recent developments have affected global commerce and the transportation industry. The second section contains a discussion

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of the effects of shifting trade patterns on Arizona's transportation system. The global shift from a manufacturing and agricultural economy to a service-based economy is discussed in the third and final section.

## ■ 2.0 The World Shrinks, The Economy Grows

### Foreign Trade Developments and Trends

In the post-Cold War era, foreign trade has become the most important contributor to the growth of the global economy. After the collapse of Communism, the former Soviet Union and Soviet Bloc countries opened their economies and, simultaneously, international trade with Latin America and the Pacific Rim countries increased. Since World War II, the United States has benefited tremendously from foreign trade. Between 1960 and 1999, the U.S. share retained a constant 12 to 14 percent share of global merchandise trade, but as a share of the U.S. gross domestic product (GDP) global trade grew from 10.7 percent in 1970 to 26.9 percent in 1999, in constant 1996 dollars.<sup>1</sup> Future worldwide growth will be fueled by further liberalization of trade policies, the spread of free market economies, and productivity growth due to advances in information and communications technologies. Corporations as well as providers of transportation services will continue to globalize in order to take full advantage of productivity gains afforded by foreign trade.

The need for unrestricted trade across borders has spawned numerous multi-national and regional trade agreements between the United States and its trading partners. The North American Free Trade Agreement (NAFTA) between Canada, the United States, and Mexico will most likely have the greatest effect on Arizona due to the State's location along the U.S.-Mexico border. However, U.S. trade agreements with Latin American, Asian, and European countries, as well as the formation of non-U.S. trade blocks such as the European Common Market, are also benefiting Arizona.

The U.S. transportation system has so far been able to adapt to changing trade patterns. The following sections describe how changes in world trade have affected business models and transportation logistics. The next section details how shifts in trade patterns between the United States and foreign countries are affecting Arizona's transportation system.

### Global Supply Chains and Transportation Logistics

The liberalization of world trade policies has allowed foreign and domestic firms to develop global supply chains, operating across borders to gain access to low-cost labor and materials. Many U.S. firms have moved production facilities out of the country – in 1993, more than 75 percent of Fortune 500 companies operated production facilities in

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<sup>1</sup> U.S. Department of Commerce, Bureau of Economic Analysis.

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Mexico, and that figure has since grown. Even those products that continue to be manufactured in the United States rely on foreign parts and raw materials. To a lesser extent, foreign firms such as auto manufacturers have built manufacturing plants in the United States in order to reduce distribution costs and gain political clout.

Coinciding with these location changes, in much of the manufacturing industry there has been a shift from “push” to “pull” transportation logistics. Pull logistics systems, which are driven by customer demand rather than the manufacturing process, are made possible by improvements in the collection and use of information at all stages of production and distribution of a product. By utilizing pull logistics, a manufacturer can reduce its stockpiles of raw materials and supplies as well as its inventory of finished products. “Just-in-time” (JIT) delivery is one artifact of pull logistics, and requires a close integration of shippers’ and manufacturers’ operations. Based on product demand, a manufacturer must coordinate deliveries from parts suppliers, who in turn must coordinate deliveries of raw materials. With pull logistics, products such as computers and even automobiles can be manufactured to order, reducing warehousing costs for manufacturers and retailers.

While a pull logistics system allows for increased productivity and reduced manufacturing costs, reliable freight transportation systems and communication systems are critical to its viability. Travel time uncertainty arises largely due to traffic congestion in metropolitan areas, at border crossings, and at intermodal transfer points. Streamlined import/export regulations as well as capital improvements and technological advances at seaports and other intermodal facilities have increased travel time reliability for transborder and multimodal shipments, leading to reductions in transportation costs for multinational firms. In contrast, urban congestion continues to steadily intensify.

Cargo theft and unanticipated system failures or disruptions due to weather, strikes, and terrorism will always threaten the practicality of pull logistics systems. Therefore, no U.S. manufacturer has developed a pure pull system to date. Fluctuations in demand and lack of certainty in supply channels both require some reliance on traditional, inventory-based push logistics.

Along with open markets and free trade, a well-developed transportation infrastructure and advanced communications technology on a global scale are prerequisites for an efficient supply chain. However, while decisions about transportation infrastructure supply are increasingly being made at the local and MPO level in the United States, multi-national corporations have a global view of transportation needs. This ideological conflict must be resolved by Arizona DOT in cooperation with federal and local agencies so that the needs of freight shipments are not overlooked in favor of local or regional passenger trips.

Changes in transportation supply due to globalization are not limited to physical infrastructure. Providers of transportation services have adapted to the changing structure of manufacturing by internationalizing and developing multimodal relationships with other firms. They have been able to better integrate both the temporal and spatial components of global supply chains due to advances in information and communications technology, providing door-to-door service with real-time shipment tracking capabilities. As freight carriers consolidate and invest in new technology and training for their employees, barriers to entry by smaller firms will rise and competition may eventually suffer. One benefit



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of industry consolidation has been the increasing standardization of communications systems and information management systems, and in particular those systems used to relay information between shippers and government agencies. The next section describes how Arizona can work with freight carriers to improve operational efficiencies through the use of information technology.

## **Transportation Applications of Information Technology**

Although many of the costs of information and communications systems are borne by private transport firms in the form of fleet management tools, Arizona's continued investment in commercial vehicle operations (CVO) technologies will lead to further productivity gains within the State, reducing the costs of doing business in Arizona. Advances in automated vehicle classification and identification have enabled trucking firms to pay registration fees and obtain necessary permits in advance of a vehicle's entry into the State. Combined with weigh-in-motion sensors, these technologies reduce inspection delays for freight shipments while lowering inspection costs for the State. By performing preliminary inspections on agriculture in Mexico before a truck reaches a border crossing, the Arizona Department of Agriculture further reduces border delays. Wherever possible, Arizona should expand preclearance and pre-inspection programs, in concert with investments in information technology at state and international borders.

Shipment verification and driver verification technologies such as Smart Cards embedded with electronic manifests and biometric information about drivers can increase the security of deliveries, and gamma ray imaging and other "hands-off" inspection technologies can quickly detect contraband and explosives, enhancing safety while reducing inspection time for sensitive, high-risk shipments into the State. Other techniques to ensure the safety and security of high-risk shipments include the use of low-tech devices such as tamper-proof container seals or more sophisticated remote monitoring systems. Once in Arizona, shipments can be tracked using radio frequency identification (RFID) tags and global positioning satellites (GPS), along with "geofencing," to ensure that a vehicle does not stray from its preassigned route.

Many information technology applications can benefit passenger as well as freight movement. Offering real-time congestion and travel time information to the public via "511" phone services, web sites, and broadcast news media allows road users and transit users to make more informed decisions about mode choice, route choice, and departure time choice. Monitoring roadways from traffic management centers and operating roaming patrols reduces incident response times and delays due to non-recurring incidents. These and other Intelligent Transportation System (ITS) technologies allow for a more efficient use of transportation infrastructure in Arizona, which indirectly benefits the economy. As new technologies such as third generation (3G) wireless services become more widespread, Arizona should expand its information distribution capabilities. The State can also directly reduce its own costs by continuing to expand the range of government services offered over the Web.

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While applications of information technology have the potential to increase transportation system efficiency, evidence exists that most of the productivity gains due to advances in technology have already been realized in the United States. When measured as a percentage of gross domestic product (GDP), total logistics expenditures, consisting of inventory expenses, transportation costs, and administrative costs, fell during the 1980s and early 1990s due in large part to decreases in inventory expenses. Over the same period, transportation unit costs have dropped, but the savings were offset by increased consumption of transportation services. In the past five years, total logistics expenditures have stalled at about 10 percent of GDP.<sup>2</sup>

Transportation system congestion and decreased travel time reliability for sensitive goods could cause logistics costs to start increasing if JIT manufacturers are forced to stockpile parts and supplies as a cushion against unpredictable variations in delivery times. Further, post-September 11 concerns about safety and security have triggered an increase in regulation in the transportation industry that threatens to **reverse** recent productivity gains. The next section discusses the combined effects of economic deregulation and safety regulation on Arizona transportation.

## **Economic Deregulation and Safety Regulation**

Since deregulation in the U.S. transportation industry began in the 1970s, productivity and competition have both increased and a once-threatened industry has returned to profitability. Large scale mergers between passenger and freight carriers allowed firms to take advantage of economies of scale and compete on a national and global level. However, it is possible that overconsolidation in the transportation industry will work to reduce competition. For instance, there are now only two national rail carriers plus one short-line railroad serving the entire state of Arizona. Only Phoenix is served by both of the national rail carriers that operate in the State. Other communities have only one choice of a carrier – if they have rail service at all.

Despite the consolidation that has taken place in the railroad industry, profits are flat and rail carriers cannot afford to make necessary capacity expansions. The railroad industry increasingly looks to state and federal governments for assistance in financing capital improvements and capacity expansions. Intercity passenger rail is not profitable under any circumstances, as demonstrated by the performance of Amtrak's long distance, intercity routes outside the Northeast Corridor. States and the federal government may have to establish a new tax or revenue source to support freight and passenger rail similar to the Highway Trust Fund and Aviation Trust Fund, both of which are funded by direct or indirect user fees. Arizona must decide if it will treat rail, and passenger rail in particular, as a government service that requires subsidy, or as an independent, for-profit entity. The decision will shape the future of both freight and passenger rail in the State.

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<sup>2</sup> Cass Information Systems Inc., *Cass/ProLogis 10<sup>th</sup> Annual State of Logistics Report*, 1998.

The air industry has performed somewhat well financially since being deregulated. After experiencing several high-profile bankruptcies and mergers, the U.S. air industry has become much more efficient and competitive. Alliances between U.S. airlines and foreign carriers have increased the ease of travel to international destinations, but so far foreign carriers have not been permitted to compete directly with U.S. airlines on domestic routes. Despite fears that monopolies would form after deregulation and the industry would not be open to competition, a relative newcomer, Southwest Airlines, has grown to be the most profitable airline in the United States, and the only U.S. airline to turn a profit in 2001.

America West Airlines, headquartered in Tempe, Arizona, is another product of deregulation. Over the course of the 1990s America West climbed from bankruptcy to profitability, but the airline was hurt by the fallout from September 11, and was forced to rely on a cash bailout from the federal government and additional federal loan guarantees to avoid bankruptcy. Since America West operates 75 percent of the commercial flights at Phoenix Sky Harbor International Airport, Arizona's economy is perhaps overly reliant on one airline's survival. Although the airline appears to be on track for long-term growth, in the event that America West should fail, Arizona should ensure that other airlines can quickly step in to provide sufficient air service to Phoenix.

After September 11, heightened security at airports has increased air travel time, resulting in small but noticeable shifts in short-haul markets. For example, since September 11 Amtrak's Northeast Corridor passenger rail service has captured a majority of the market share for travel between Washington, D.C. and New York for the first time in Amtrak's history. While these shifts may not affect the demand for passenger rail in Arizona, shifts from air travel to intercity bus routes and passenger cars may persist long after the aftershocks of September 11 subside. New security procedures will require modifications to air terminals and may affect the operations of quick-turnaround airlines such as Southwest.

Heightened security also has required additional inspections for vehicles entering the country from Mexico. These inspections have increased delay and transportation costs for transborder freight shipments. Countering this trend is raising political pressure to relax weight and safety requirements for commercial vehicles entering from Mexico. Arizona must ensure the safety of its citizens, but also should be aware of tools that facilitate the flow of freight and passengers throughout the State while at the same time maintaining a high level of safety and security.

### ■ 3.0 Effects of World Trade on Arizona's Transportation System

#### Shifts in Trade Patterns within the United States and Arizona

Regardless of where production facilities are located and which shipping firms transport freight, there will continue to be a need to distribute manufactured goods and agricultural products to consumers and businesses in Arizona and the rest of the United States.

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Currently, freight and passengers pass into and out of Arizona primarily using one of three modes:

1. Along interstate highways and other roads at Arizona's borders with other U.S. states, or at one of six Arizona-Mexico international border crossings;
2. Along one of the two east-west trunk rail lines that pass across Arizona, along short lines or trunk line spurs from other states, or at a U.S.-Mexico border crossing; or
3. By air.

These three modes of entry are affected in different ways by U.S. trade with its various trading partners. Growth in trade with Pacific Rim countries, along with America's continued strong trade relationships with European countries, has increased the importance of east-west transportation infrastructure in the United States. Meanwhile, the emergence of Latin America as a strong trade partner coupled with the influence of NAFTA on the U.S. economy has begun to impact both border crossings and north-south corridors leading to the borders and to Gulf Coast ports. Finally, the technology sector has increased the flow of high-value, time-sensitive goods traveling by air cargo and less-than-truckload (LTL) shipments, which impacts both the air system and distribution routes in Arizona's metropolitan areas. The next three sections discuss the importance of east-west and north south trade, border crossings, and air cargo shipments to Arizona's economy, and how the state's transportation system must evolve so that the State can capture the most economic benefit from changing world trade patterns.

### ***East-West Trade***

Although East Asian economies suffered from near-total collapse in the late 1990s and have yet to fully emerge from a severe depression, strong economies in the United States and Europe have continued to fuel rapid expansion of east-west trade patterns that were first established in the age of the railroads. The transportation system in the western U.S. is primarily composed of strong east-west links. The transcontinental railroads first joined regions east of the Mississippi with the Pacific coast in the 19<sup>th</sup> century and, later, the interstate highways stretched westward across the plains and cut through the Rocky Mountains on their way to western port cities.

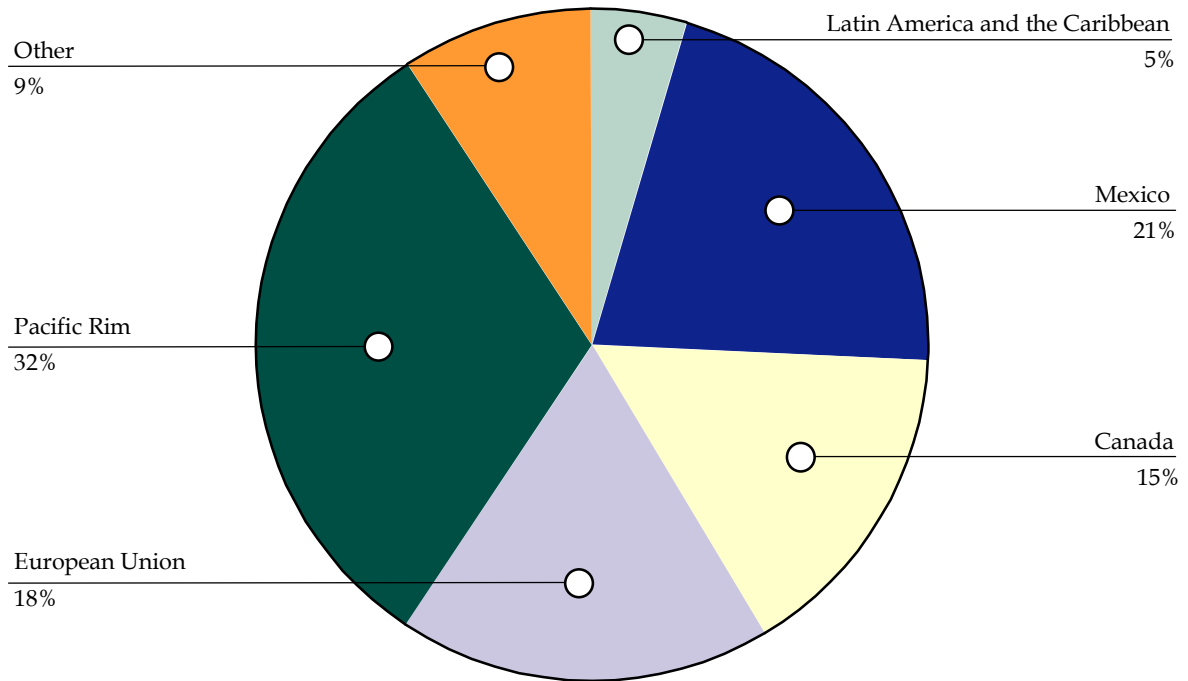
These transportation links originally allowed goods to move between manufacturing centers on the East Coast and agricultural and mining areas in the West. Over time, as trade with Europe strengthened and Asian markets opened up to U.S. trade, east-west transportation links were essential to the upsurge of imports and exports between the U.S. and overseas markets. In just the past decade, the value of U.S. exports to Western Europe and Pacific Rim countries has more than doubled, and the value of U.S. imports from those regions has increased by 62 percent.<sup>3</sup> The Pacific Rim accounts for one-third of Arizona's exports by value, as shown in Figure 1. Arizona exports more goods to the

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<sup>3</sup> U.S. Bureau of the Census, Foreign Trade Division.

Pacific Rim than to Mexico, when measured by value, and the State's exports to the European Union are just below levels of exports to Mexico.

**Figure 1. Arizona Export Destinations, 2000 (by Value)**



While most Asian import and export traffic passes through Arizona on its way to and from other states, Arizona must keep up with demand for freight movements on existing east-west trans-state corridors, all of which pass through the State's major metropolitan areas and impact local traffic. The most important east-west freight routes in Arizona are the two transcontinental interstate highways and the two rail trunk lines that traverse the northern and southern portions of Arizona, and around which the majority of development in the State has taken place.

Interstates 10 and 40 connect the Port of Los Angeles to the Southern and Southwestern Sunbelt states. The ports of Los Angeles and Long Beach, combined the fourth busiest port in the United States,<sup>4</sup> have over 50 percent of the U.S. market share for trans-Pacific shipments<sup>5</sup>, and the sunbelt has been the most rapidly growing region in the United States for half a century. In addition, I-10 and I-40 both serve as export routes for agricultural and manufactured goods produced in Arizona and California, and the two interstates provide

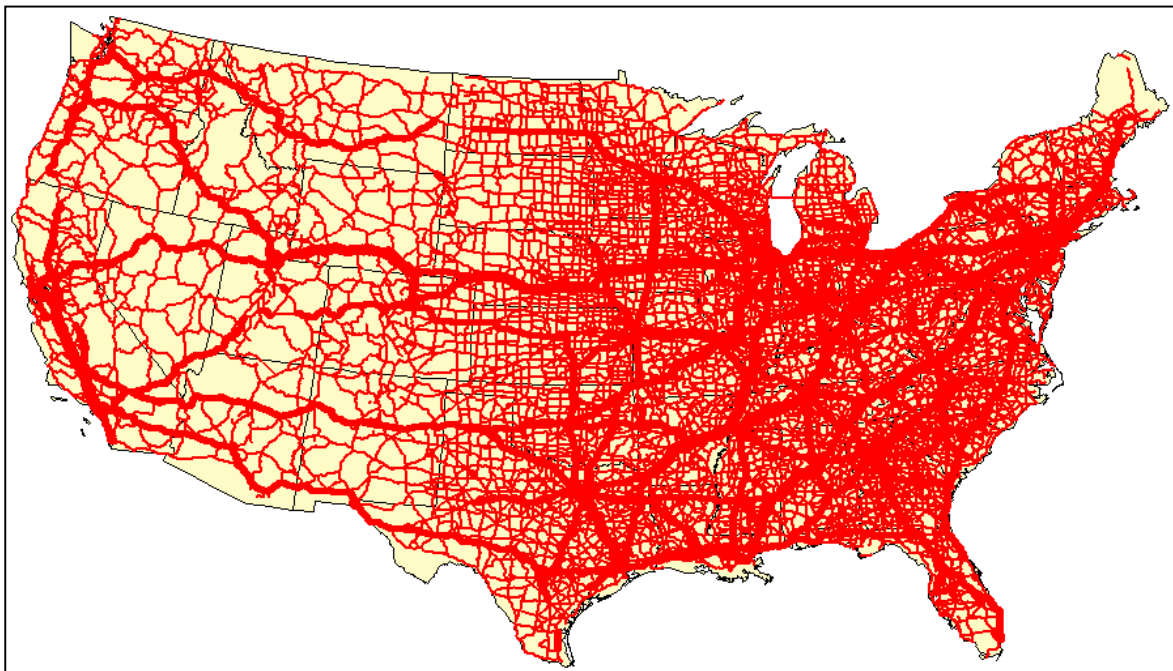
<sup>4</sup> U.S. Army Corps of Engineers Navigation Data Center.

<sup>5</sup> Los Angeles Port Authority.

direct or indirect access to ports on the Gulf Coast and the Eastern Seaboard. Seventeen percent of the truck traffic on Interstate 10 in Arizona passes directly through the State from Southern California to New Mexico and 16 percent of I-10 truck traffic originates in Arizona with a destination in either Southern California or a point east of Arizona.<sup>6</sup>

Figures 2 through 4 demonstrate the importance of I-10 and I-40 to the movement of freight exports from Arizona and across Arizona to other states. Figure 2 shows the relative magnitudes of truck freight flows on highways in the United States. Interstates 10 and 40 clearly stand out as thick lines on the map in the southern and northern portions of the State, respectively, with the heaviest flows in Arizona shown between Phoenix and Tucson along I-10. Figure 3 shows a forecast of U.S. truck traffic produced by overseas shipments arriving at U.S. ports. Clearly, growth at the Port of Los Angeles and other U.S. ports will have a significant impact on Arizona as traffic increases on I-10 and I-40. Finally, the destination of freight that originates in Arizona is shown in Figure 4. Interstate 10 plays a vital role in the movement of freight exports out of Arizona. Note that the thickness of a line on any of the three maps is relative to that map for maximum clarity, so each map is drawn to a different scale. Therefore, line thicknesses cannot be compared across maps.

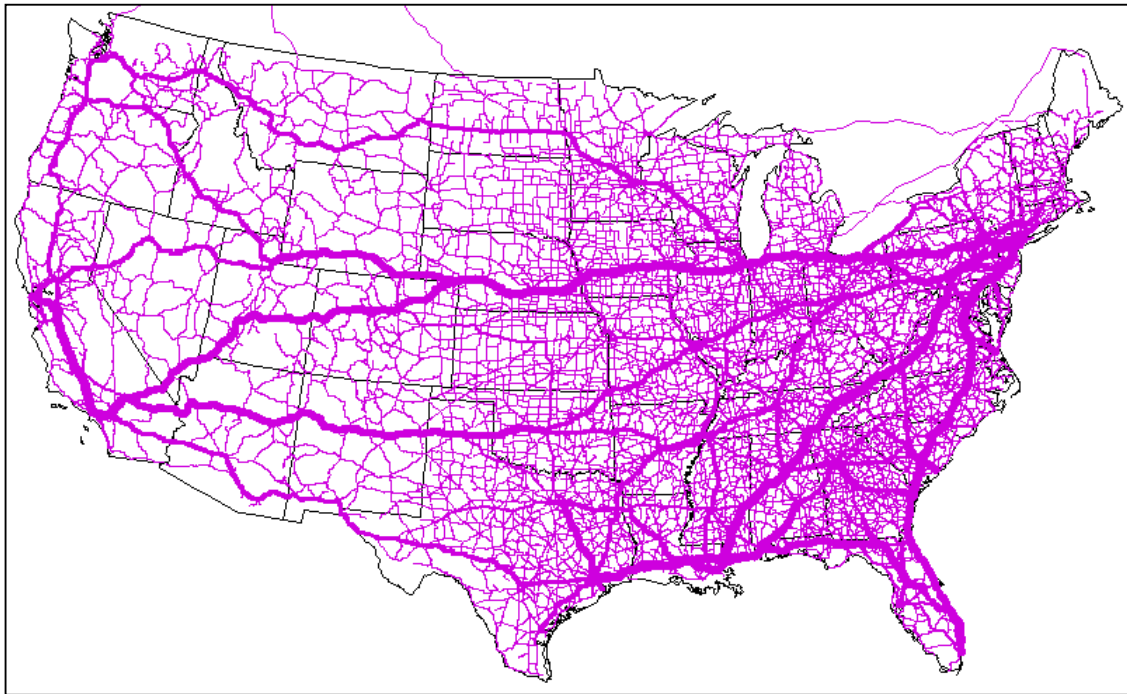
**Figure 2. Domestic Truck Freight Flows (Tons)**



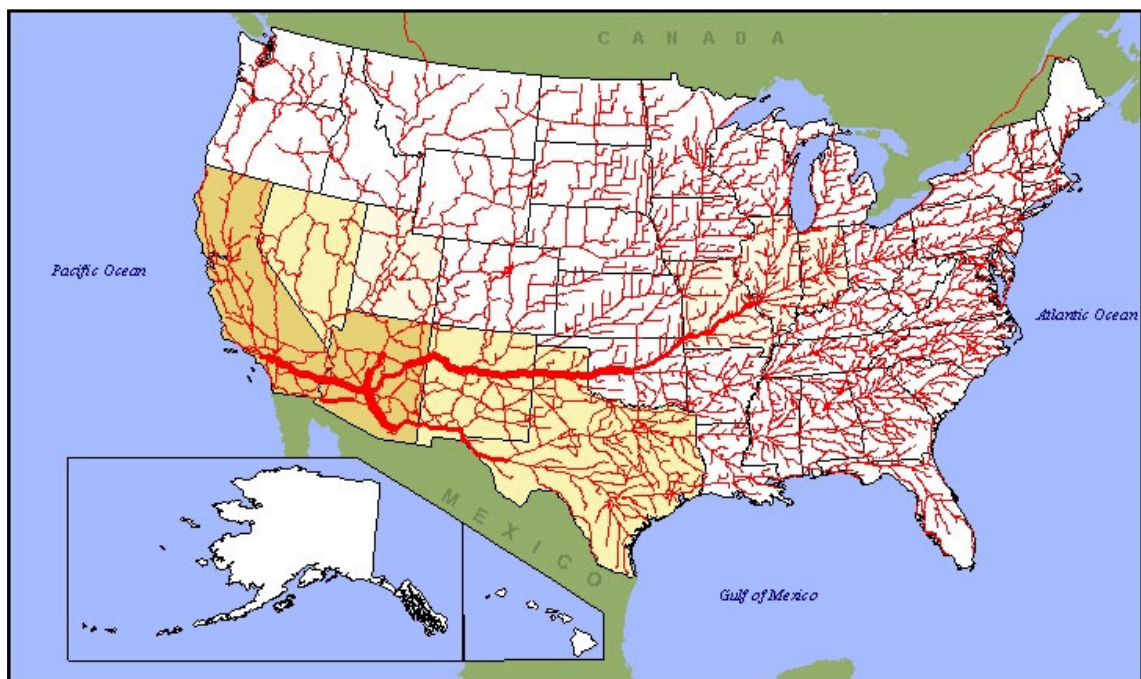
<sup>6</sup> CANAMEX Corridor Coalition, 2001, *CANAMEX Corridor Plan*, prepared by Economic Research Associates.



**Figure 3. Truck Traffic Produced by Overseas Shipments Arriving at U.S. Ports, 2020 Forecast (Tons)**



**Figure 4. Domestic Truck Flows for Freight Originating in Arizona**



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In the future, as U.S. trade with China increases and the Asian economy rebounds from its current recession, imports through the Port of Los Angeles will continue to increase. The construction of the Alameda Corridor, coupled with Los Angeles' capability of handling "post-Panamax" supercontainer ships, further cements the port's position as a major generator of freight traffic for I-10 and I-40 for years to come.

In order for Arizona to sustain economic growth, the Department of Transportation must continue to maintain or improve levels of service on the I-10 and I-40 corridors so that the flow of east-west interstate traffic is not hindered. On the I-10 corridor, the Phoenix and Tucson metropolitan areas present the biggest bottlenecks for freight traffic. As a whole, the I-40 corridor is uncongested, but sections of the interstate in Flagstaff and near Kingman could be threatened by future growth in traffic. Capital improvements such as new roadway construction and capacity expansions will be necessary, but Intelligent Transportation System (ITS) investments can improve the efficiency of Arizona's highways at a much lower cost than traditional capital improvements.

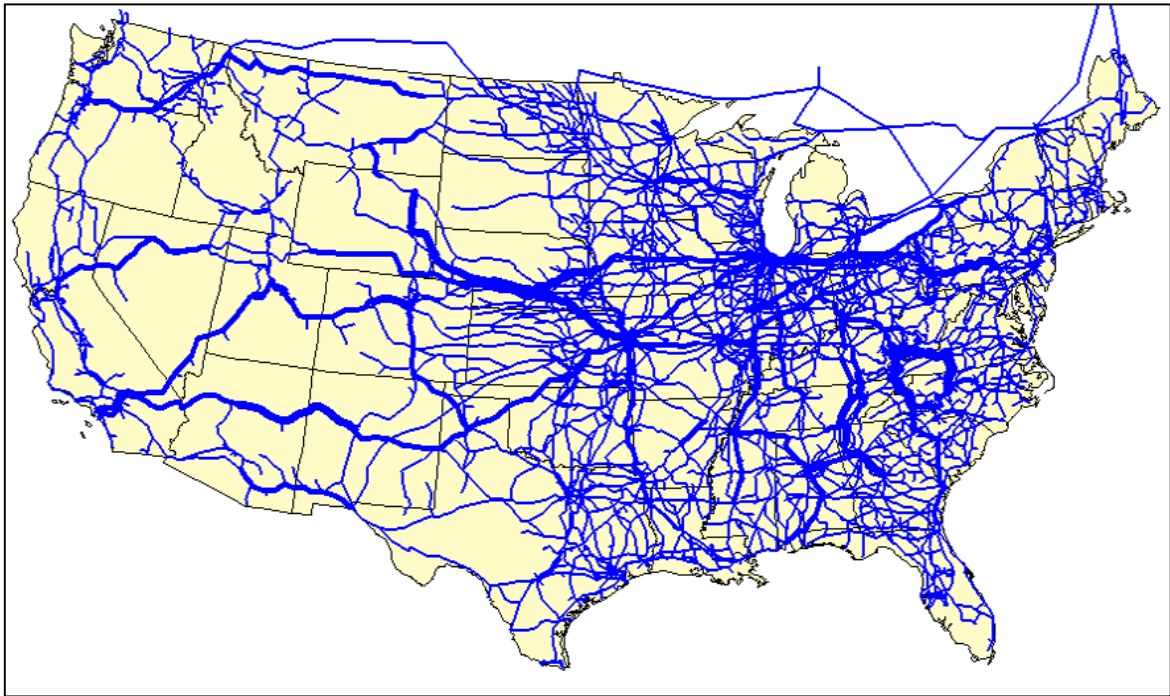
The Alameda Corridor and the rise of the supercontainer ship will not only affect interstate truck traffic. Increasingly, containers are being offloaded from ships directly onto rail cars. Improved communications and freight tracking systems combined with automated container loading and unloading systems will reduce the cost of transporting containers by rail, improve travel times by rail, and enhance the attractiveness of rail for long-distance freight traffic. Arizona's two trans-state rail lines will absorb much of the increase in rail freight traffic generated by the Ports of Los Angeles and Long Beach.

The Burlington Northern Santa Fe (BNSF) Arizona Main Line, running across northern Arizona from Topock to Dennison roughly parallel to Interstate 40, carries the majority of trans-state rail traffic in Arizona. The line has double-stack capability and is not severely constrained within Arizona. Currently, a major rail bottleneck at Cajon Pass, California, is the biggest impediment to further increases in rail traffic on the BNSF line, but growth in rail traffic from the Ports of Los Angeles and Long Beach, California, that is bound for the Midwest may eventually require a significant capital investment to expand rail capacity through Arizona, especially through Kingman Canyon. Another east-west rail line, which roughly parallels Interstate 10, is operated by Union Pacific Railroad. While the UP rail line carries significantly less freight than the BNSF line, the rise of manufacturing in Northern Mexico will fuel an increase in traffic bound for U.S. distribution centers and Pacific and Gulf ports. The implications of U.S. trade with Mexico for Arizona's transportation system will be discussed in the next section.

Figure 5 shows the freight flows by rail in the United States. The BNSF line in Northern Arizona carries the largest volume of freight, followed by the Union Pacific Line between Picacho and the New Mexico border in Southeastern Arizona.



**Figure 5. Domestic Rail Freight Flows (Tons)**



Both the BNSF and UP rail lines have numerous at-grade crossings in Arizona. To improve the efficiency of freight operations and eliminate traffic congestion at rail crossings, Arizona should continue to work with BNSF and UP to construct new grade separations wherever practical. Cash-strapped rail firms are increasingly looking to state governments to help fund rail improvements on privately owned rail lines, especially for grade separations and projects related to passenger rail. Any future passenger rail programs in Arizona must consider the effects of passenger rail operations on freight traffic so as not to impede the growth of rail freight. Many types of freight can be more efficiently carried across Arizona by rail rather than by truck. By increasing the attractiveness of rail as a transport mode, Arizona can draw both current and future freight traffic away from highways to the railroads.

#### ***North-South Trade and Border Crossing Issues***

While American trade with Asia and Europe has added freight traffic to the nation's east-west transportation system, NAFTA and other trade agreements with Mexico and Latin America are generating increased demand for north-south travel within the United States, and international trade between the United States, Mexico, and Canada has put a strain on border crossings. In order to take full advantage of economic opportunities offered by increased trade with Latin America, Arizona must address deficiencies in its north-south corridors and, in particular, at its main U.S.-Mexico port of entry at Nogales.

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U.S. trade with Mexico, Canada, and Latin America has increased dramatically over the past decade. Imports and exports to both Mexico and Latin America have tripled in value; imports and exports from Canada have doubled in value. Although Latin America as a whole has not grown as quickly as expected due to the Mexican peso crisis in 1994, among other factors, the region is expected to lead the world in economic growth over the next two decades. Arizona's ties to Mexico are already strong, and the State can expect exports to the rest of Latin American to grow rapidly with the region's economy. In 2000, Arizona exported one-fourth of its manufactured goods, by value, to Mexico and Latin America, making this region Arizona's top export destination.<sup>7</sup>

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the National Highway System Designation Act of 1995 (NHS), and the Transportation Equity Act for the 21<sup>st</sup> Century (TEA-21) established a high-priority transportation corridor running from the Mexican border at Nogales, Arizona, to the Canadian border at Sweetwater, Montana. Known as the CANAMEX corridor, the route follows Interstate 19, Interstate 10, and U.S. 93 from Nogales to the Hoover Dam crossing of the Colorado River at the Nevada state line, running southeast to northwest across Arizona through Tucson, Phoenix, and Kingman.<sup>8</sup> The CANAMEX corridor also extends south from Nogales along the Gulf of California to Mexico City in Central Mexico, and north from the Canadian border to Edmonton, Alberta. The corridor will link Arizona to manufacturing centers in the Mexican State of Sonora, just south of the border, and also to population centers in Central and Southern Mexico. To the north, the corridor connects Arizona to Las Vegas and Salt Lake City.

Although there is more international freight moving on Arizona sections of I-10 than on I-19 (the route connecting I-10 with the international border at Nogales) the U.S.-Mexico border crossings at Nogales plays an important role in the movement of freight between Arizona and Mexico. The three border crossings at Nogales on the CANAMEX corridor serve trade between Arizona and the *maquiladora* industry in Sonora. Nogales is also the largest port of entry for winter vegetables in the United States, processing over 60 percent of Mexican produce exports to the United States each year.<sup>9</sup>

Due to traffic congestion and lack of connectivity with Eastern and Central Mexico, the volume of freight traffic passing through Nogales has fallen from fourth place to sixth place in the United States.<sup>10</sup> In the weeks after September 11, 2001 delays at Nogales were severe, even though traffic levels dropped by close to 50 percent.<sup>11</sup> Traffic has not yet

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<sup>7</sup> U.S. Department of Commerce, International Trade Administration.

<sup>8</sup> CANAMEX Corridor Coalition, 2001, *CANAMEX Corridor Plan*, prepared by Economic Research Associates.

<sup>9</sup> University of Arizona Department of Economic Development, Southwest Border Technology Project.

<sup>10</sup> Ibid.

<sup>11</sup> Araiza, A. E., 12/8/01, *Border Wait Times Back to Normal*, Arizona Daily Star, Tucson, Arizona.

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returned to normal levels as of the time of this writing, but it is certain that traffic and congestion at the border will intensify as trade between Arizona and Mexico increases.

Several steps have already been taken to improve the flow of commercial vehicles through Nogales in anticipation of future increases in traffic, including a U.S. Federal Highway Administration (FHWA) demonstration project called Expedited Processing at International Border Crossings, or EPIC, which allows commercial vehicle cargo to be pre-cleared by U.S. customs before arriving at the border. EPIC is a precursor to the planned International Trade Data System (ITDS), which will allow the U.S. government to collect data on transborder shipments and allow shippers to preprocess customs forms over the Internet. In addition, advanced inspection technology, including gamma ray imaging equipment, has been installed at Nogales to quickly detect contraband and explosives before they enter the United States without requiring trucks to be unloaded and inspected manually. Advances in information technology could cut border crossing times by as much as eight minutes per vehicle, resulting in a 5.4:1 benefit/cost ratio. Arizona should continue to lobby for the latest information and inspection technology advances at the Nogales border crossings to allow passenger and freight to move across the U.S.-Mexico border as efficiently as possible, while ensuring that safety and security standards are met.

Although improvements are being made to the Nogales border crossings and to Arizona's other major international border crossings at San Luis and Douglas, further investments in transportation infrastructure will be necessary inside Arizona near the border. The State of Arizona's Safety Enforcement and Transportation Infrastructure Fund (SETIF) provides revenue for the enforcement of vehicle safety requirements by the department of public safety, and the maintenance of transportation facilities, including roads, streets and highways as approved by the Arizona Transportation Board within 25 miles of the border between Arizona and Mexico. SETIF funds can also be used for the maintenance and construction of the transportation facilities in the CANAMEX corridor. Funds are appropriated by the Arizona Legislature.

Funds in the SETIF could be used to improve access from the single commercial vehicle crossing in Nogales to I-19, for example, and to widen and improve I-19 as conditions warrant. The entire length of Interstate 19 is forecast to operate at level of service D or E by 2010 and level of service F by 2020 if only budgeted improvements are made.<sup>12</sup> Since there are no adequate east-west roads or railroads in Northwestern Mexico and just two minor rail lines connect Arizona with the neighboring northern Mexico State of Sonora, much of the freight traffic generated in Sonora that is bound for U.S. seaports, air cargo facilities, and truck-to-rail intermodal transfer facilities will enter Arizona by road. Improved connections from San Luis to I-8 at Yuma are also necessary, and a better access route from I-10 to the Douglas crossing would provide commercial vehicles bound for New Mexico and points east a better alternative to the Nogales port of entry.

Beyond the border, other portions of the CANAMEX corridor will need to be upgraded by 2020. Interstate 10 through Tucson and Phoenix and U.S. 60 leading northwest out of

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<sup>12</sup>Ibid.

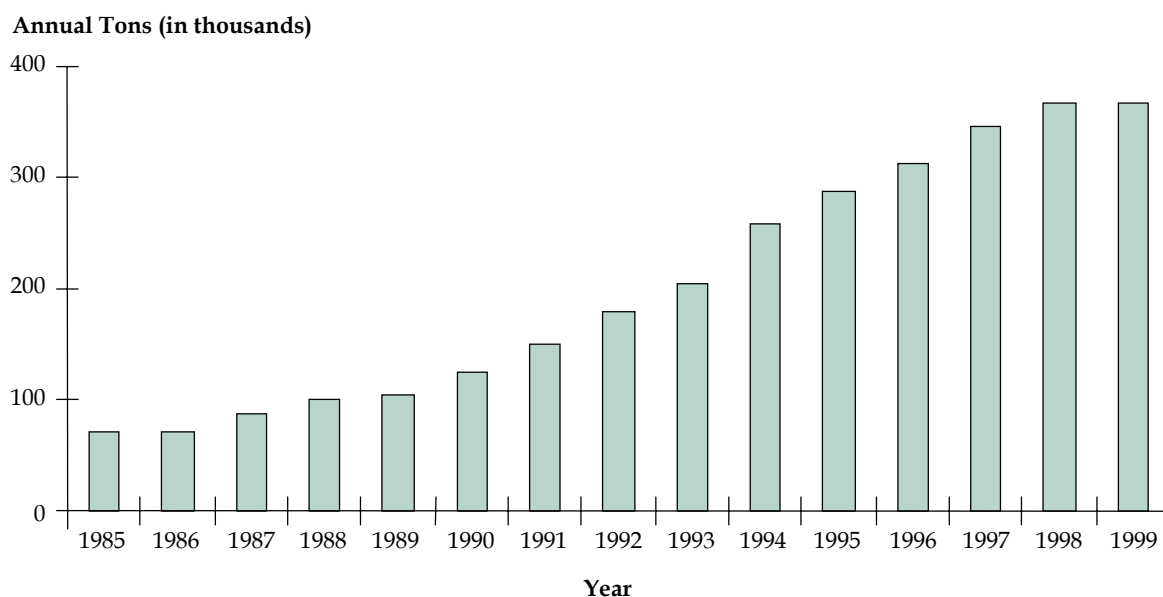
Phoenix are other predicted traffic choke points. Several widening projects to upgrade U.S. 93 from a two-lane to a four-lane highway between Wickenburg and I-40 are underway or are under study. These projects should be completed as quickly as possible. With the completion of the Hoover Dam Bypass project, a major bottleneck on U.S. 93 between Phoenix, Las Vegas, and points north will be eliminated.

There are no interstate highways or rail links between Arizona and Utah, the State's northern neighbor, aside from a tiny section of Interstate 15 that slices through the extreme northwest corner of Arizona. Currently, central Arizona traffic destined for Salt Lake City and the I-15 corridor must use U.S. 93 and face the Hoover Dam bottleneck and the congested Las Vegas metropolitan area, or drive north on U.S. 89 through Page, a two-lane, windy route. The only rail route from Nogales to Las Vegas and Salt Lake City requires a long detour through Southern California, since no direct rail routes exist between Arizona and Utah. Arizona could benefit from increased trade with other CANAMEX states by improving transportation links to the North.

### *Air Cargo and Air Passenger Travel*

The importance of high-value, time-sensitive shipments has led to a rapid expansion of air cargo in the United States. At the same time, reductions in the cost of air travel due to deregulation and increased competition have contributed to congestion in the nation's air system due to high levels of demand and lack of supply. Each of these trends has been experienced at Arizona's main hub airport, Phoenix Sky Harbor International Airport. Figure 6 shows the growth in air cargo shipments at Sky Harbor since 1985.

**Figure 6. Total Cargo Traffic at Phoenix Sky Harbor International Airport**



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Open skies agreements with Asian countries have enabled U.S. freight carriers to establish overseas hubs. In order to continue the healthy growth in air passenger and freight travel at Sky Harbor and its spillover effects for the State's economy, Arizona should facilitate to the greatest extent possible an increase in nonstop freight flights to Asia, and nonstop passenger flights to Europe, South America, and Asia. Nonstop passenger flights, especially to overseas destinations and U.S. cities not easily served by truck or rail, will help air cargo traffic expand at Sky Harbor. In addition, nonstop passenger flights to a wide variety of destinations will make the city more attractive to corporations seeking new locations for headquarters and regional offices.

Sky Harbor International Airport's central location in Phoenix is both a strength and a weakness. Proximity to downtown reduces average travel time to the airport for all Phoenixians, but the airport will soon run out of room for runway expansion, which will limit its long-term growth prospects. Complaints about noise from overnight freight flights and increased passenger flights will only continue to grow as the airport expands. Williams Gateway Airport in Mesa or a new airport between Phoenix and Tucson could serve as reliever airports for both passenger and freight traffic, but Arizona must act immediately to plan for a new or expanded airport and acquire sufficient land to accommodate the demand for passenger and air cargo traffic. Airports in Southern Arizona also will experience a growth in cargo traffic as the maquiladora industry across the border in Sonora, Mexico, expands. The Yuma and Tucson airports will absorb most of the additional traffic coming across the border from Mexico.

New security procedures required at U.S. airports since September 11, 2001 have affected both the capacity of the air system and the demand for travel by air. As total travel time by air increases, the competitiveness of alternative intercity travel modes increases. Meanwhile, the operations of air carriers have been affected by the new federal security requirements. Air carriers such as Southwest Airlines that depend on quick turnaround times may see their operational efficiencies suffer and their competitive advantage disappear due to the new safety procedures. The air system still has a long adjustment period ahead before the effects of September 11 on air travel are fully understood.

Sky Harbor has already begun to reconfigure its air terminals to accommodate additional baggage screening equipment and passenger security checkpoints. Federal funding for security improvements will partially offset these unanticipated costs, but the airport will be responsible for paying for additional security measures as part of any future terminal design and construction.

## ■ 4.0 From “The Five C’s” to “The Big S”

### The Transformation of Arizona's Economy

Every Arizona schoolchild learns about the “Five Cs” of Arizona's economy: Copper, Cattle, Cotton, Citrus, and Climate. While each of these economic factors continues to

play an important role in Arizona's current economy, each has diminished in importance due to the rise of one "Big S": Services.

Globalization and the expansion of free market economies has led to worldwide productivity increases, which in turn has facilitated the rise of the service sector in industrialized and developing nations. Along with the entire U.S. economy, Arizona's economy is led by the service sector, which has added nearly a quarter of a million jobs since 1993, and now employs almost one out of every three Arizonans.<sup>13</sup> Arizona has witnessed one of its five Cs, the copper industry, decline as low-cost foreign imports flooded the U.S. market. Agriculture has shed more than half of its employment in the past decade, but productivity gains have contributed to this decline. Manufacturing continues to account for almost 10 percent of Arizona's employment and provides the second highest-paying jobs in the State after mining.<sup>14</sup> Table 1 shows the change in employment by sector in Arizona from 1993 to 2001.

**Table 1. Change in Arizona Employment by Sector, 1993 to 2001**

Employment Sector	1993		2001		1993-2001
	Employment	Percent	Employment	Percent	Change
Services	460,500	26%	699,200	30%	238,700
Mining	12,200	1%	9,100	0.4%	-3,100
Construction	98,100	6%	160,200	7%	62,100
Manufacturing	180,000	10%	202,300	9%	22,300
Transportation and Public Utilities	81,100	5%	108,300	5%	27,200
Wholesale Trade	81,000	5%	110,300	5%	29,300
Retail Trade	322,100	18%	425,000	18%	102,900
Finance, Insurance, and Real Estate	105,400	6%	151,300	7%	45,900
Government	290,600	16%	381,400	16%	90,800
Agriculture	151,536	9%	72,881	3%	-78,655
<b>Total</b>	<b>1,782,536</b>	<b>100%</b>	<b>2,319,981</b>	<b>100%</b>	<b>537,445</b>

Source: U.S. Department of Labor, Bureau of Labor Statistics. Figures for 2002 are preliminary.

The rise of the service sector was made possible by productivity improvements in agriculture, manufacturing, mining and other resource extraction, and communications.

<sup>13</sup>Ibid.

<sup>14</sup>Arizona Department of Economic Security, 2001.

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These productivity improvements continue today as technological advances allow for more efficient manufacture and movement of goods – and now information – around the globe. The “24-hour shift,” a relatively new phenomenon, allows assignments and tasks to follow the sun, passing electronically from English-speaking workers in Australia and Asia to India, Europe, America, and finally back across the Pacific. While manufacturing jobs were the first to leave America for cheap labor markets elsewhere, increasingly firms are establishing customer service and technical support centers overseas.

As described in previous sections, the advent of “pull” logistics allows manufacturers to reduce warehousing of finished products, and in some cases products are built to order. With the rise of e-commerce and the convenience of purchasing goods, customers are demanding fast, reliable, and on-time delivery of all products. These shipments are best handled by less-than-truckload (LTL) deliveries and parcel shippers such as UPS and FedEx. Demand for small package shipments is expected to rise, while business-to-business shipments via full trucks and railcars will decrease. The largest component of growth in freight traffic will be delivery trucks moving over regional highway and arterial networks.

Unfortunately for Arizona’s overburdened roads, the rise of the service economy translates to more urban congestion. This is not to say that demand for high-volume transportation services will decline; instead, growth in the service economy will stimulate demand for fossil fuels, agricultural products, and bulk materials that can easily be transported by rail or sea. The demand for high-capacity transportation will continue to increase, but the share of goods transported by rail and water will level off or decrease.

Freight carriers are under intense pressure to keep their costs low while providing superior service to their customers. Carriers are working with shippers to improve logistics by consolidating shipments into larger units, which allows for more efficient transportation of goods. Integrating such tasks as moving returned items backwards through the retail supply chain has given rise to third-party and even fourth-party logistics providers.

With more information and choices at their disposal, consumers, businesses, and even transportation employees expect (and can demand) a high quality of service and a broad range of choices or incentives from freight carriers. Consumers find it easier to find information on a particular product or service and have more options as they decide where to spend their money. Businesses expect improved service from suppliers and their carriers. Employees find it much easier to change careers or jobs today than in the age of manufacturing, when each job required a specialized skill and families were much less mobile.

In Arizona, the service economy will require continued expansion of metropolitan highway networks in order to accommodate increases regional freight traffic in addition to ever-increasing passenger traffic generated by population growth. Arizona’s transportation investments will be guided by residential and commercial development patterns, but the State can also use improvements to the transportation system as a tool to influence future development patterns. The next section describes changes in development patterns that can be expected as a result of the service economy.

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## The Service Economy's Impact on Development Patterns

The rise of the service economy has not only changed the business climate in Arizona; it also has changed the way Arizonans live, where they work, and how they travel. From an economic and quality of life standpoint, the characteristics and pattern of development in Arizona has been the most significant impact of the service economy's dominance. Migration from manufacturing states in the North and Midwest to the Sunbelt was made possible by the economic mobility and freedom offered by the service industry. Looking for a high quality of life in a warm climate, workers swarmed to Arizona over the past 20 years. As the State's population continues to increase at a rapid pace, Arizona is faced with both challenges and opportunities related to transportation and development.

Up to this point, development has occurred around major Arizona cities in a low-density, dispersed pattern. Wide open spaces and cheap land in the Southwest allows home owners to buy relatively large single-family homes on large lots, and flexible, inexpensive transportation provided by private automobiles permits residents to live as far from employment, shopping, school, and recreation as they desire. Service-oriented firms have moved their headquarters and back-room operations to office parks that offer ample parking. In the service economy, firms depend on the transfer of information, which reduces the benefits of economies of agglomeration. Firm location choices are no longer limited to central business districts or other concentrations of employment.

Even the location of production facilities has changed. Manufacturing plants for high-tech products do not generate large amounts of pollution, and they consume mostly electricity and water. These facilities are still dependent on adequate, reliable transportation for the delivery of supplies from parts manufacturers. But instead of receiving bulk supplies like coal or steel via a river barge or a train, the factories receive 24-hour deliveries by truck, typically of smaller materials, components, and sub-assemblies. Likewise, finished goods are shipped out by truck to a U.S. distribution facility, or to an air cargo facility or a seaport for overseas transport.

As population has exploded in Phoenix and Tucson, the land area consumed by development also has increased rapidly. Much of this increase in metropolitan area size can be attributed to population growth, however, as opposed to inefficient land use. In Arizona, the acres of developed land per capita actually *decreased* 13 percent between 1982 and 1997, compared to a 16 percent increase in per capita land consumption in the U.S. as a whole over the same period.<sup>15</sup>

Arizona's transportation infrastructure has not been able to accommodate the increased demand without added congestion. This increase in congestion has taken its toll on commuters in Arizona's largest metropolitan areas and caused several areas of Arizona to fall into nonconformity with Clean Air Act air pollution standards. To address congestion problems, Maricopa County communities have chosen to invest in light rail to serve the most dense population and employment centers in the region, while advancing an

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<sup>15</sup> U.S. Department of Agriculture Natural Resources Inventory, 1997.



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aggressive freeway expansion program. Tucson is improving its existing road network and also is considering light rail.

A range of transportation solutions, including expansions of freeways and local roads, new and expanded transit services, and pedestrian and bikeway improvements is necessary to handle projected increased in traffic demand if Arizona is to preserve its economic vitality and sought-after quality of life. Along with capital improvements, the continued implementation and expansion of Intelligent Transportation System (ITS) technologies will allow Arizona to improve the efficiency of its existing and planned transportation infrastructure. Value pricing and managed lanes are other methods of managing travel demand on congested urban roadways while providing a source of revenue for future highway capacity expansions or transit investments.

Transportation and development are inextricably linked, and decisions in both areas will impact economic vitality in the State. Any improvements in transportation made by the State will affect development patterns, and in return that development will generate demand for travel on the State's transportation system. In Maricopa County, sharp increase in residential and commercial real estate prices and new home and office park construction in anticipation of the completion of Loop 101 and Loop 202 are strong evidence of the relationship between transportation system expansion and development patterns. While the new freeway loops are currently relatively free of congestion, future development on the outskirts of the Phoenix metropolitan area will ultimately lead to traffic congestion on the new highways as well.

While transportation planning in Maricopa and Pima Counties is controlled by regional authorities, there are no corresponding authorities with the ability to regulate land use on a regional scale. Multiple jurisdictions in each area have independent land use rules and regulations. The Governor's Vision 21 Task Force has recommended that the State establish urban regional transportation and land use districts. With a regional perspective, these types of agencies can steer area-wide development to desired development zones, where existing transportation infrastructure or investments planned for the near future can best handle increases in traffic. These regional agencies may also have more influence with the State Land Department, and might reduce the incidence of large tracts of land being sold to single land owners, who then develop the land without regard for the current state of local infrastructure.

Regional agencies in other states also have the power to modify zoning laws to facilitate the construction of affordable housing. Although housing affordability is not a major concern in Arizona today, experience in other Sunbelt cities such as Austin, Texas suggests that as congestion increases, housing prices near employment centers will rise above levels that are affordable to teachers, police officers, and others who provide basic public services. Arizona must take steps to avoid future housing affordability issues, since it will not always be possible for people to simply move further out to the metropolitan fringe. Investments in mass transit will help low-to-medium income residents access jobs. Another Vision 21 Task Force recommendation calls for the State to begin coordinating transportation and land use planning. State-of-the-art travel demand models incorporate land use forecasts that allow for more accurate predictions of future travel patterns.

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Development-induced demand for travel is currently the largest cause of inaccurate travel demand forecasts. Integrated transportation and land use planning also will allow Arizona to better conserve natural resources and reduce the impacts of development due to a new transportation facility on environmentally sensitive areas.

As the service economy grows and people continue to move to Arizona, the State should be prepared for expansion in all of its urban areas, including not just Maricopa, Pinal, and Pima counties, but also in areas surrounding Nogales, Yuma, and Flagstaff. With state-of-the-art tools and new perspectives on transportation and land use planning, Arizona will be in a position to shape the future growth of the State, rather than simply reacting to development patterns using spot improvement to transportation infrastructure.

## ■ 5.0 Conclusions

Arizona is faced with a range of challenges and opportunities stemming from shifts in international and domestic trade patterns, transformations in business logistics, improvements in the transfer of information, and the rise of the service economy.

Liberalization of world trade policies has allowed firms to globalize their operations. Global supply chains and the advent of pull logistics have reduced manufacturing and logistics costs, but firms are increasingly reliant on predictable freight travel times. The reduced cost of storing and communicating information has made just-in-time delivery and made-to-order manufacturing a possibility for new economy and old economy firms, and as a result less-than-truckload and small parcel shipping is expected to generate the largest share growth in the freight shipping industry over the long term.

Economic deregulation has led to consolidation and expansion in many areas of the economy, including the transportation industry. Freight shippers have globalized their operations to better serve their multi-national clients. Competition in freight and passenger rail has all but disappeared, but even with near-monopolies, freight railroads and Amtrak both may require government subsidies to make future capital improvements on aging, capacity-constrained infrastructure. Airlines have fared better than railroads, but the aftereffects of 9/11 have yet to be fully realized. Stricter security regulations will impact ground transport as well as air transport. At border crossings, preinspection and improvements in technology can ease congestion and delays for passengers and freight.

In order to take advantage of the economic growth in the service economy, Arizona must address issues related to freight transport from, to, within, and through the State. The efficiency of freight transport is impacted by congestion at border crossings, at inspection facilities, on urban freeways and arterials, at rural bottlenecks, and on routes used to access intermodal transfer facilities. Improvements in communications technology promise to increase productivity for freight shipping firms while reducing Arizona's administrative costs. Well-developed transportation infrastructure is essential to the efficiency of supply chains.

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Freight movement has long been overlooked by transportation planners, but the movement of passengers is no less important. Although the service economy emphasizes the movement of information rather than goods, decentralization of business has influenced business location decisions and shaped urban development patterns, which in turn has had profound impacts on urban transportation infrastructure in Arizona. Arizona has the opportunity now to integrate transportation and land use planning so that state and regional planning organizations can exert more control over future development decisions. Improved regional cooperation in land use and transportation planning can have a variety of benefits, economic and otherwise, from protecting environmentally sensitive areas to maintaining a sufficient supply of affordable housing in rapidly growing urban areas.

Although Arizona has been transformed since the days when the “Five Cs” powered the State’s economy, a superior quality of life is still one of the State’s strongest assets. Maintaining and improving Arizona’s transportation system will be critical to preserving a high standard of living in the State and allowing the State’s economy to prosper.

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# Transportation and Land Use

# **Transportation and Land Use**

**DRAFT**

**A white paper**

**Prepared for the**

**Arizona Department of Transportation**

**March 26, 2002**

**By**

**Edward Beimborn, Ph.D.**

# **Transportation/Land Use White Paper**

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## 1. Introduction

Sometime in the next thirty to forty years Arizona will double in population. This will mean the addition of five million more people. For every person and building now in the state, space will be needed for another. There will be enough people for another Phoenix, another Tucson, another Quartzite, another Bisbee and a duplicate of every community in the state. All that now exists will have to be duplicated in some way to accommodate this growth. In short, the growth of the state means that a second Arizona will be needed to be created to sit beside the present one.

The doubling of Arizona assumes that growth will continue at a rate similar to that of the past. Arizona has been one of the fastest growing states in the country. During the last forty years the population of Arizona has increased by 380%, going from about 1.3 million people in 1960 to over 5 million people by the year 2000 census. Most of this growth has come from migration. This

has been primarily from the northern and eastern parts of the United States and other countries, especially Mexico and countries in South and Central America. The population of Arizona is not only much larger, but it is also far more diverse than it has been in the past.

People move to Arizona for a variety of reasons. It is a state of extraordinary natural beauty that draws people from all over the world as tourists and as permanent residents. The climate and environment make it a top choice for people seeking a place to retire or to escape harsh winters and cold weather. To those outside the state, Arizona is a state of great opportunity as a place to get a job or start a business. Growth leads to growth as more people arrive and who need more services and who provide jobs for the next round of arrivals.

If past patterns continue, the need for additional land for a doubling of population will be far more than twice the land now used for the current population. Recent growth patterns everywhere have led to lower densities and higher rates of land consumption. For example, since 1970, the population of the Los Angeles area increased by 45%, but at the same time the land area has increased by 300%. Similar patterns occurred in other major cities around the country including those in Arizona.

The population of the state will likely differ substantially from that of today. The population will be older and much more diverse. People who migrate to the state will include large numbers of people looking at it as a place of retirement and will also include large numbers of immigrants from other countries who will see the state as a place with good opportunities to work and live.

What the state does to deal with this growth will have a profound affect on the very nature of Arizona and what it means to its citizens. The impact of future

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*"Sometime in the next thirty to forty years the population of Arizona will double."*

*"...a second Arizona will be need to be created to sit beside the present one"*

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growth in the state will be profound, irreversible, and massive. Major questions will arise about the adequacy of water resources, energy supply, and impacts on the natural environment. The open spaces that draw people to the state will become increasingly more distant to those who live in metropolitan areas. Once an area is converted to urban and suburban use, it will remain that way forever. What the growth will do to the state is not known, but unless there are significant changes in migration and life style trends in the population, the fact that it will occur is a certainty. How it happens and how the state and local governments react is a critical question, for policies that are set now will shape the state in the future.

If past trends continue, the population growth will carry with it a growth in travel at least as great and most likely greater. Travel will more than double, adding major increases in traffic and congestion to state

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*“How the state deals with transportation and land use will be one of the most critical questions facing the state in the future”*

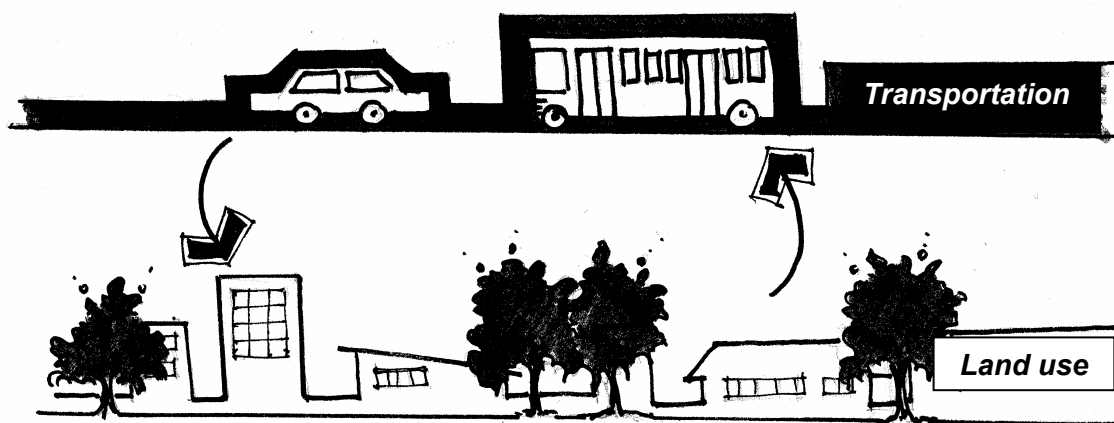
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highways. This trend will only change if there are new patterns of development such as more compact land use or if there is a shift to other modes of travel besides the single occupant automobile. Other modes of travel will only play a minor role unless there are significant changes in how they fit into land use patterns. To deal with this in the normal way of doing business will require funding levels far beyond those available today. How the state deals with transportation and land use will be one of the most critical questions facing the state in the future. The transportation of the state will affect this growth and be affected by it. The decisions made now about transportation made now will have effects that will have major long-range effects. Good policy and plans (transportation for smart growth) should be a high priority. This will involve greater understanding of land use-transportation interaction by ADOT staff and local governments and a wider set of tools and options to work with.



## 2. Land Use – Transportation Interactions



### 2.1. Overview

The connection between transportation and land use is a fundamental concept in transportation. Everything that happens to land use has transportation implications and every transportation action affects land use. Actions by transportation agencies shape land use by providing infrastructure to improve accessibility and mobility. This increases the utility of land and leads to more intensive land use. Land development generates travel, and travel generates the need for new facilities, which in turn increases accessibility and attracts further development. The question of whether transportation influences development or whether land use dictates transportation has been a matter of ongoing concern among transportation professionals since the beginning of transportation planning.<sup>1</sup> There is no simple answer to this question, both happen together and there is a need to consider both simultaneously.

A state department of transportation is just one of the many organizations that influence land use. Land use decisions are the result of complex interaction of many forces involving individuals and organizations in both the public and private sectors. There are many factors in the land development process. These include overall population and economic growth, market

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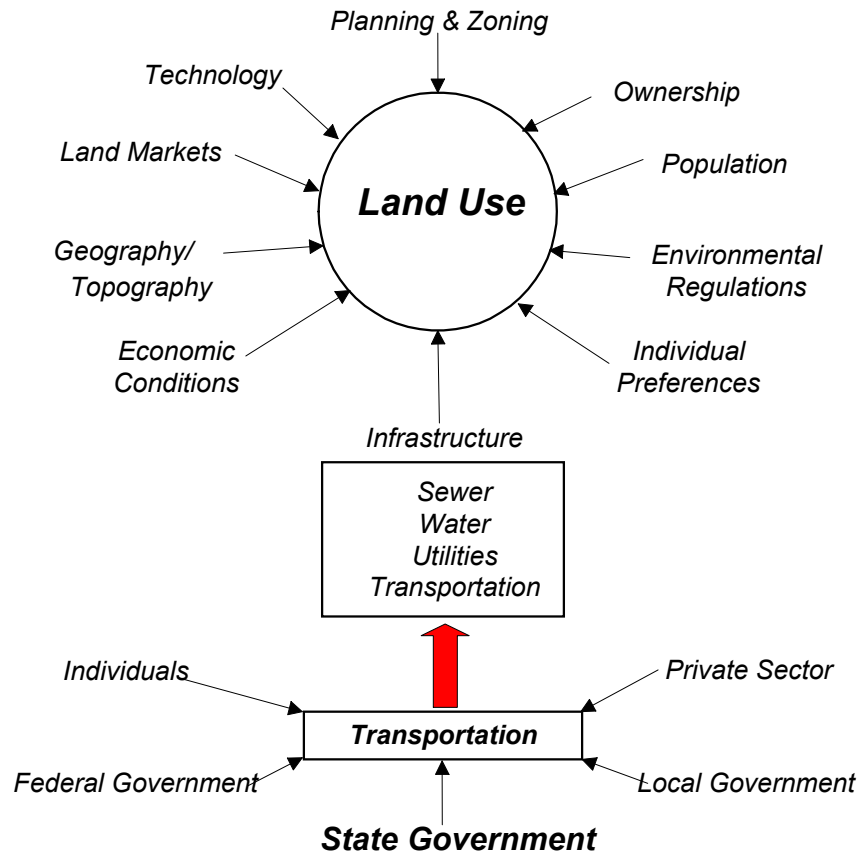
*"Everything that happens to land use has transportation implications and every transportation action affects land use."*

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<sup>1</sup> This section has been adapted from "An Overview: Land Use and Economic Development in Statewide Transportation Planning," Report by the Center for Urban Transportation Studies, University of Wisconsin Milwaukee to FHWA, May 1999.

conditions, individual preferences and life style choices, other infrastructure, changing technology, local planning and zoning polices and geographic and topographic conditions.<sup>2</sup>

**Figure 1. Transportation's Role in Land Use**



[Source for Figure: Indirect and Cumulative Effects Analysis for Project Induced Land Development, WisDOT 1996]

The easy response that a transportation agency could take to this situation is to ignore the land use implications of what they do with a feeling that it is beyond their control and impossible to deal with. Such an approach is short sighted, leading to long term consequences that negate the benefits of transportation investments. Transportation and land use are closely intertwined and the implications of transportation decisions on land use cannot be ignored.

A state DOT influences land development through providing infrastructure and through transportation-related regulations. State transportation projects are normally planned to improve safety, decrease travel time by alleviating congestion, and achieve other mobility-related goals. Seldom are projects

<sup>2</sup> Adapted from *Indirect and Cumulative Effects Analysis for Project Induced Land Development; Technical Reference Guidance Document*. Wisconsin Department of Transportation, 1996.

planned or designed with land use issues as a primary objective.

Transportation's impact on land development occurs at many levels. This ranges from simple actions such as issuing a driveway permit to overall actions such as the development of strategic plans and programs. When improved access is provided to land, it raises its potential for development, and more development generates additional travel. Once access has been provided, land patterns begin to change over a period of time. The results of these changes are, for the most part, irreversible.

## 2.2. Emerging Land Use Concerns

Recently, concerns about urban sprawl have arisen in many areas of the nation. Many diverse groups have common concerns about the role transportation plays in exacerbating or combating the problems associated with urban sprawl, suburban congestion, and jobs/housing mismatches. Some people have argued that efforts to expand the highway system contribute to urban sprawl by decreasing travel times from urban to exurban/rural areas and making undeveloped areas attractive for residential and commercial uses. Often new highway facilities in urban areas have driving times and levels of congestion that exceed that of the highways they replace, suggesting that new or expanded facilities may be unable to solve long-term congestion problems.<sup>3</sup>

Several factors can be identified as contributing to sprawl, including the movement of jobs to suburbs, lower transportation costs versus lower housing costs, preference of many people to live in remote areas away from the problems of the city, and the desire for larger residential lots and units.

Sprawl is a concern for many because of its impact on open space and agriculture. Diverse groups, including farmer organizations, inner-city community organizations, transit advocates, and environmental organizations, have worked together in some areas to deal with issues of sprawl. It can lead to adverse impacts in areas where people are moving as well as in the areas they are moving from. Of recent concern are labor shortages created by jobs/housing mismatches. Housing markets in the suburbs have excluded many skilled laborers who would traditionally be employed by the industries and commercial enterprises that develop in these areas. A combination of transportation and land use measures is needed to address this problem.

The concern about sprawl and transportation has led to a new debate in many states and communities about the relationship between transportation and land use. In some cases, local and statewide efforts are now beginning to take effect to limit sprawl in some of the nation's fastest growing urban areas. The new debate invariably involves state DOTs, whose role in land use decision-making continues to evolve.

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<sup>3</sup> Adapted from Guiliano, Genevieve. "The Weakening Transportation Land Use Connection." Access, No. 6, spring 1995. University of California at Berkeley, pp. 3-11.

Perhaps one of the most useful documents about sprawl is Transit Cooperative Research Program Report 39, "The Cost of Sprawl Revisited"<sup>4</sup>. This report offers a comprehensive review of literature related to urban sprawl and its effects. The report provides a working definition of the term sprawl and includes an analysis of nearly 500 documents that deal with the topic. Literature on sprawl is summarized under the categories of: public/private capital and operating costs, transportation and travel costs, land/natural habitat preservation, quality of life and social issues. Under each topic area the project team determined the degree of agreement among researchers if a condition existed, if it was positive or negative and if it was linked to sprawl. Forty-one issues were identified and many of them dealt with transportation directly or indirectly. It presents one of the easiest ways to gain a quick understanding of land use issues and provides a basic background on the topic.

The researchers concluded that there is a general agreement in the literature that sprawl leads to more vehicle miles of travel, more automobile trips and less cost effective transit services. There was also some agreement that sprawl means higher household costs of travel and greater social costs. No clear outcome exists in the literature reviewed that sprawl reduces congestion, requires longer travel times or lowers the government costs of transportation.

Other work<sup>5</sup> compared the differences in infrastructure cost for 'sprawl' development (a tendency towards lower densities) vs. 'planned' developments (with somewhat higher densities and mixed uses) and found that costs of roadway infrastructure was about one fourth to one half lower with planned development. School infrastructure costs were similar in both cases while utility costs were also lower by one third to one tenth. Planned development can result in lower costs through more compact design and better viability for other modes, such as transit, walking, and bicycles.

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*"there is a general agreement in the literature that sprawl leads to more vehicle miles of travel, more automobile trips and less cost effective transit services."*

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One message not directly found in the literature is that how land use and transportation interact is something that is not beyond the control of local and state governments. How, where and when land use occurs is something that can be affected if there is the will to do it. If a transportation agency takes no actions that affect land use, then land use will dictate transportation. New facilities will tend to follow development and attempts will be made to provide facilities to meet population and economic growth. In such a case the transportation agency merely reacts to growth and stays out of land use issues.

On the other hand if an agency adopts a more aggressive policy towards land use, then land use will be affected. Such a policy requires cooperation and

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<sup>4</sup> Burchel et al. "The Cost of Sprawl Revisited." *Transit Cooperative Research Program Report 39*, Transportation Research Board, 1998.

<sup>5</sup> R. Burchell. "Economic and Fiscal Costs and Benefits of Sprawl." *The Urban Lawyer*, Vol. 29, 1997.

agreement with local governments charged with making land use decisions. For example, if there is consensus that growth should not occur in a certain area, then local government has to take steps to direct it elsewhere or to lessen its impact. These steps might include very low-density zoning, purchase of development rights and other policies to reduce future trip making. Transportation agencies have to agree to not expand facilities in those areas and to work with local and regional organizations to implement their plans.

### 3. Scope of State DOT Actions that Affect Land Use<sup>6</sup>

There are many ways in which a state DOT is involved in land use. These include project level activities as well as systems planning and policy. Project activities relate to how a project is designed, how access is provided and managed, and how the project provides connections to other areas. Project level activities also include how provisions are made for a variety of travel modes, especially public transit, bicycles and walking. Systems level activities include land use and transportation planning, economic development and improving the capabilities of staff within the DOT as well as at the local level.

The role a state adopts in each of these areas can vary along a broad spectrum ranging from very active involvement in the coordination of transportation and land use to a very passive role, where the state leaves most of the decision-making to others. In order to help understand the spectrum of activity that states may undertake, a chart has been developed from previous work to show the range of state transportation activities that relate to land use. A state's role can be defined along a continuum from active to passive in the following six categories.

- ◆ Land Use/Transportation Planning Requirements
- ◆ State Land Use Planning Capabilities
- ◆ Education/Technical Assistance
- ◆ Access Management
- ◆ Land Use Controls
- ◆ Economic Development

Each of these categories is described below.

#### 3.1. Land Use/Transportation Planning Requirements

At the passive end of the continuum, a state could fund regional- and local-level planning and leave the decision-making entirely to local jurisdictions. The option to do planning and how it is done is left to the local agencies. At the most active level, the state itself is responsible for planning and zoning, as is done in Hawaii. Between these two ends of the spectrum is state mandated local planning where the state sets mandatory standards for land use plans or may set guidelines reflecting the state's interests. A passive approach would require the planning to take place but not require state approval of the plans. A more active strategy

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<sup>6</sup> "An Overview: Land Use and Economic Development in Statewide Transportation Planning," op. cit., Chapter 2.

would require that local land use decisions must have state approval and certification.

A critical issue related to this is the extent to which the state defers to local or regional planning agencies in transportation decisions. It is inconsistent on one hand to strongly believe that land use decisions should be made at the local level and then to build projects that weaken the ability to implement those plans. For example local plans may state the need to have a compact development pattern while state actions lead to the expansion of roadway capacity outside those areas.

### 3.2. State Land Use Planning Capabilities

The state DOT can provide a range of capabilities to assist local agencies, depending on how involved it wants to be in the planning process. As shown in the chart, these activities would range from providing data collection services for local government, at the passive end, to the utilization of sophisticated state land use models and basic research, at the active end. The purpose of transportation/land use models is to predict the future impact of transportation investments on land use. Oregon and New Jersey are two states using transportation/land use models. Intermediate state services would include providing GIS assistance, policy research, and economic forecasting.

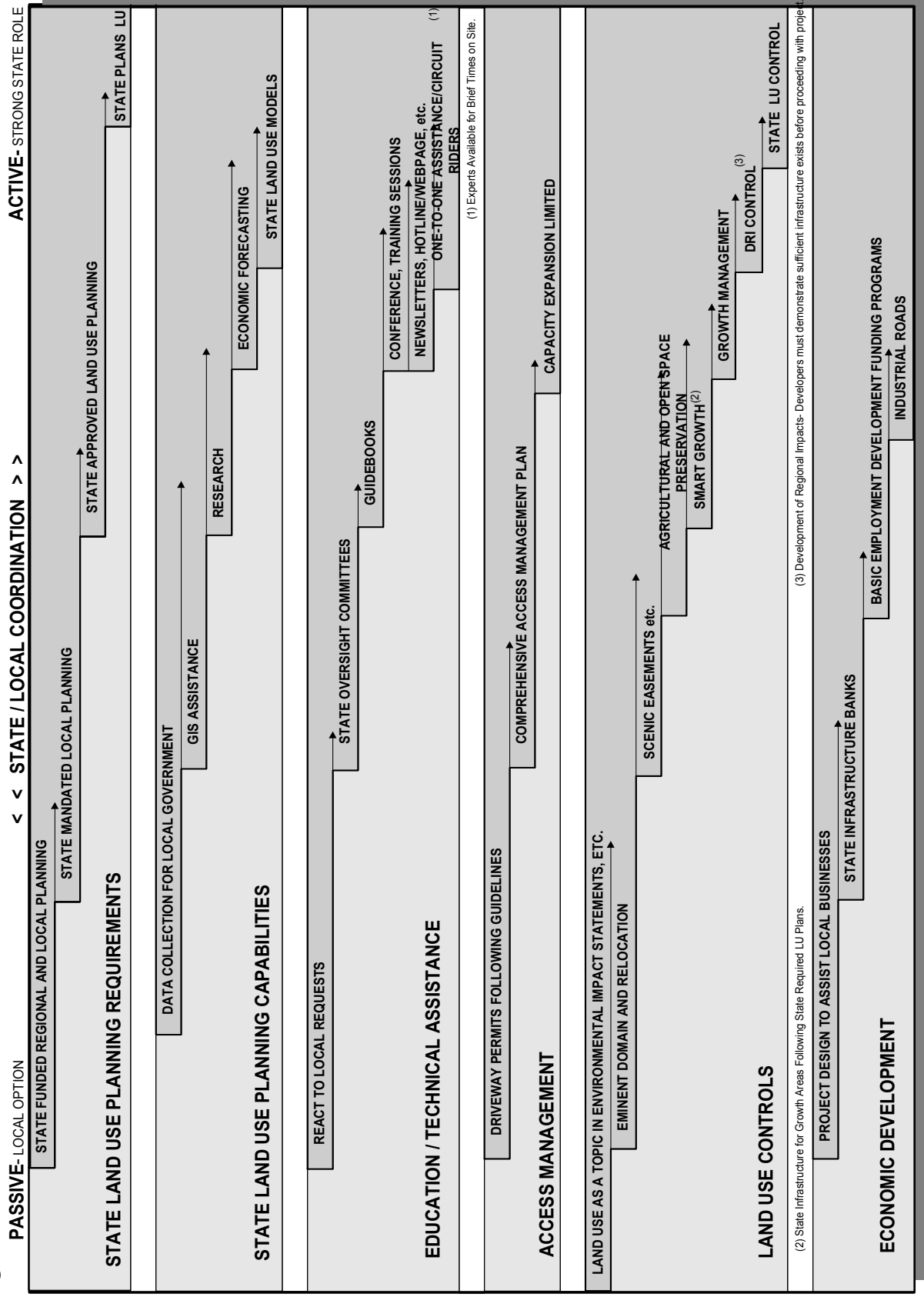
### 3.3. Education and Technical Assistance

State participation in education and technical assistance can take many forms. At the passive end of the continuum, states only react to local requests for assistance. A more active state participation would include formulating state guidelines, convening oversight committees, providing conferences, holding training sessions, issuing newsletters, organizing a hotline or Web site, providing public education, etc. At the most active level of participation, the state would provide one-to-one assistance to local government for the analysis of land use implications of transportation decisions.

### 3.4. Access Management

Access management is a systematic approach to providing appropriate access to land development on highways. The chart shows the range of access management programs that states have adopted. A passive approach is to allow unlimited access to the state highway system as long as access points follow site-specific guidelines. A more active strategy involves the development of comprehensive access management plans and policies. The most active strategy is to limit capacity expansion only to designated areas according to a statewide growth management policy.

**Figure 2. State Local Coordination**





### 3.5. Land Use Policy

Land use initiatives by a state encompass a broad range from simply including a topic in transportation plans or environmental impact statements to completely controlling land use. The various options available to a state involve different degrees of participation by state and local agencies in project-level land use policy and the project's environmental impacts, land use policy in environmentally sensitive areas, smart growth, scenic easements, agricultural and open space preservation, growth management and influences on large-scale developments. Smart growth programs bias the provision of state infrastructure to designated growth areas following land use plans done at the local level. For example, the State of Maryland restricts the expenditure of state highway funds to areas designated for development according to local plans that have been written by governmental agencies, developers, and local officials. A variety of states have adopted growth management programs. Developments of Regional Impacts (DRI) controls in some states require a developer to demonstrate that sufficient infrastructure exists before proceeding with the project.

### 3.6. Economic Development

Economic development spans a range of activities that includes project design assistance to local businesses, state infrastructure banks, funding programs to promote basic employment opportunities, industrial roads, and provision of road facilities by the state for developments that generate both basic and non-basic employment. Examples of state funding programs that facilitate economic development are the RISE program in Iowa and the TEA programs in Wisconsin and California. State infrastructure banks (SIB) are funds for infrastructure investment generated at the state or regional level, as pioneered in Ohio and Florida. Industrial road programs pertain to the allotment of funds by the state towards improving existing road facilities that enhance accessibility to eligible industrial and agricultural facilities.

## 4. Examples from Other States

Every state has a unique history and setting. What works one place may not work elsewhere because of different legal frameworks, attitudes, or population. What works elsewhere may not work in Arizona. Nonetheless, examples from other rapidly growing states provide possible land use policies that might apply to the Arizona context. Three states - Florida, Tennessee, and Kansas - provide examples of state actions linking land use and transportation.

### 4.1. State Land Use Planning Requirements – An Example from Florida

The state of Florida has had rapid growth for long periods of time and has been struggling to provide transportation capacity to go along with the growth. Florida's program to deal with land use transportation interactions was enacted through the Local Government Comprehensive Planning and Land Development Regulation Act. The central theme of this program, administered by the Department of Community Affairs, is to address the problem of urban sprawl.

The Florida legislation uses the following methods to address the interaction between transportation and land use:

- ◆ **Integrated planning:** Each MPO develops and updates a comprehensive plan including land use, highway, and transit elements. These plans must be locally adopted and approved by the Department of Community Affairs according to its growth management standards. Four-fifths of the state is within an MPO.
- ◆ **Compliance:** All Florida DOT roadway projects must be in compliance with the local comprehensive plan for the specific project's limits.
- ◆ **Coordination:** An FDOT district staff member sits as a nonvoting member at all MPO committee and board meetings.
- ◆ **Objectivity:** All goals, objectives, and policies, as well as the future land use and traffic circulation maps in local plans must be supported by and based on specific data and analyses.
- ◆ **Concurrency:** "Public facilities and services needed to support development shall be available concurrent with the impacts of such development." New developments are not allowed if they prevent a local government from maintaining an established level of service. This is the cornerstone of the growth management process.
- ◆ **Large Developments:** All developments of regional impact (DRI) undergo a special state planning process. A DRI includes "any development which, because of its character, magnitude, or location, would have a substantial effect upon the health, safety, or welfare of

citizens of more than one county.”<sup>7</sup> For example, for a proposed industrial park, the DRI review might be necessary for parking facilities of more than 1,500 vehicles or a minimum site extent of one square mile. Developers might be required to make contributions to the transit system that provides service to the area of development.

Experience with this process has been mixed. Developers have found ways to get around the regulations and communities sometimes find that there are unintended consequences. Developments have been sized to fit just under the limits or located just outside the boundaries of the MPO to circumvent the intent of the law. Furthermore, an initial shortage of state staff expertise led the state to rely on information provided by developers that minimized the negative impacts of their projects. Nonetheless, the legislation has changed the rules and led to a process for planning and growth in the state that considers how local communities cope with growth.

A partial solution was found in the adoption of the Florida Quality Developments Program. This provided developers with an incentive to use the DRI process, rather than design developments just below the threshold. The program allows the state to review and resolve problems early in the process, and to delegate the review of DRIs to local governments that show they have the capacity to review a DRI.<sup>8</sup>

## 4.2. Land Use Controls – An Example from Tennessee

The Tennessee Growth Boundary Policy Act was intended to influence the distribution of TEA-21 funds within the state. This act required every county in the state to write a comprehensive land use plan adopted by the local governing body.<sup>9</sup> These plans address transportation and public infrastructure needs in each county and must comply with the TDOT’s goals.<sup>10</sup> Some of the goals of these plans include:

- ◆ Providing for adequate infrastructure prior to development;
- ◆ Reusing developed land within existing growth boundaries instead of adding infrastructure and annexing new areas for development;
- ◆ Redesigning the existing network of roads to revitalize urban centers;
- ◆ Avoiding exclusionary zoning; and
- ◆ Encouraging mixed-use development.

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<sup>7</sup> *Ask DCA: Development of Regional Impacts (DRIs); Community Planning*, Florida Department of Community Affairs, summer 1998. Vol. 7, Number 2. p. 10.

<sup>8</sup> Adapted from: (a) CH 28-24 Developments Presumed to be of Regional Impact; (b) Development of Regional Impact (DRI) Review; (c) Rules of the Department Community Affairs Division of Resource Planning and Management Schedule for the Transmission and Submission of Local Government Evaluation and Appraisal Reports; (d) Development of Regional Impact Application for Development Approval under Section 380.06, Florida Statutes.

<sup>9</sup> Pfitzer, Jeff. “Transportation Planning and Tennessee’s Growth Boundary Policy Act: A Few Issues to Consider.” *Transportation Planning*, fall 1998. p. 1.

<sup>10</sup> *Ibid.*, p. 2.

According to this act, each Urban Growth Boundary (UGB) should demarcate a reasonably compact region with the capacity to accommodate 20 years of residential, industrial, and commercial growth.<sup>11</sup> It is the responsibility of the local planning agency to manage and control urban expansion outside of such established growth boundaries.<sup>12</sup> The municipality must consider the impacts of urban expansion on the surrounding agricultural lands, forests, recreational areas and wildlife management areas.<sup>13</sup> If growth cannot be accommodated within the specified growth boundary, then the municipality should identify potential new areas adjoining the existing high growth areas so that they can easily be incorporated into the network of road, utility infrastructure, and public services.<sup>14</sup>

This act reinforces the need for smart growth, especially in those less-developed areas that are now growing rapidly.<sup>15</sup> With the implementation of Tennessee's Growth Boundary Policy Act, every county in Tennessee effectively adopted a comprehensive plan by July 2001.

#### 4.3. Access Management – An Example from Kansas

The Corridor Management Policy adopted by the Kansas Department of Transportation (KDOT) is directed at achieving best use of the state highway system. The act establishes criteria and procedures necessary to obtain reasonable access to abutting properties while maintaining safety and efficiency in the movement of people and goods on the state highway system.<sup>16</sup> The policy is also meant to establish uniformity in the management of state corridors in Kansas. The provisions of this policy act do not constitute a specific set of legal requirements. Rather, the act sets minimum standards for access installations and establishment of protected corridors.<sup>17</sup> The main purpose of this policy is to establish methods of corridor management that lead to a minimization of vehicle conflicts, improvements in safety and traffic operations, a reduction of delays and smaller major capital expenditures.<sup>18</sup>

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<sup>11</sup> *A Guide for Conducting County Level Land Use Plans*; Tennessee Growth Policy Act Project: Fulfilling the Potential of Law; School of Planning, University of Tennessee, Knoxville. p. 1. <http://planning.cap.utk.edu/tgp/pubc1101.html>.

<sup>12</sup> *Ibid.* p. 2.

<sup>13</sup> *Loc. cit.*

<sup>14</sup> *Ibid.* p. 3.

<sup>15</sup> *Smart Growth*; Tennessee Growth Policy Act Project: Fulfilling the Potential of Law; School of Planning, University of Tennessee, Knoxville. p. 1. <http://planning.cap.utk.edu/tgp/pubc1101.html>

<sup>16</sup> *Corridor Management Policy*; Kansas Department of Transportation. p. 1.

<sup>17</sup> *Ibid.*, p. 2.

<sup>18</sup> *Loc. cit.*

The Corridor Management Policy specifies four access management objectives:

- ◆ In order to minimize the number of conflicts, eliminate driveways by combining access points or providing access from other roads.
- ◆ Achieve better separation of conflict points by providing wide spacing between driveways and keeping driveways away from intersections.
- ◆ Allow for slower deceleration through geometric changes.
- ◆ Provide exclusive turning lanes so that turning vehicles and queues are separated from through traffic.<sup>19</sup>

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*“The main purpose of this policy is to establish methods of corridor management that lead to a minimization of vehicle conflicts, improvements in safety and traffic operations, a reduction of delays and smaller major capital expenditures.”*

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KDOT can also purchase access rights to property or additional right-of-way.<sup>20</sup> When choosing the strategy for access control, KDOT considers a wide range of factors, such as patterns of development, travel demand, environmental issues, and efficient use of resources.<sup>21</sup> All issues pertaining to corridor management are reviewed and managed by the Corridor Management Committee. The KDOT coordinates its efforts with local agencies and landowners in order to effectively implement the guidelines specified in this policy.

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<sup>19</sup> Loc. cit.

<sup>20</sup> “Policy Application”; Corridor Management Policy; Kansas Department of Transportation. p. A-1.

<sup>21</sup> Loc. cit.

## 5. Application to Arizona

Figure 2 provides a framework for the state DOT to consider in evaluating its land use and transportation policies. The state DOT can take steps to implement transportation objectives seeking to improve the link between transportation, land development, and economic development. Critical decisions about how the state DOT works with local and regional agencies and the private sector lie ahead.

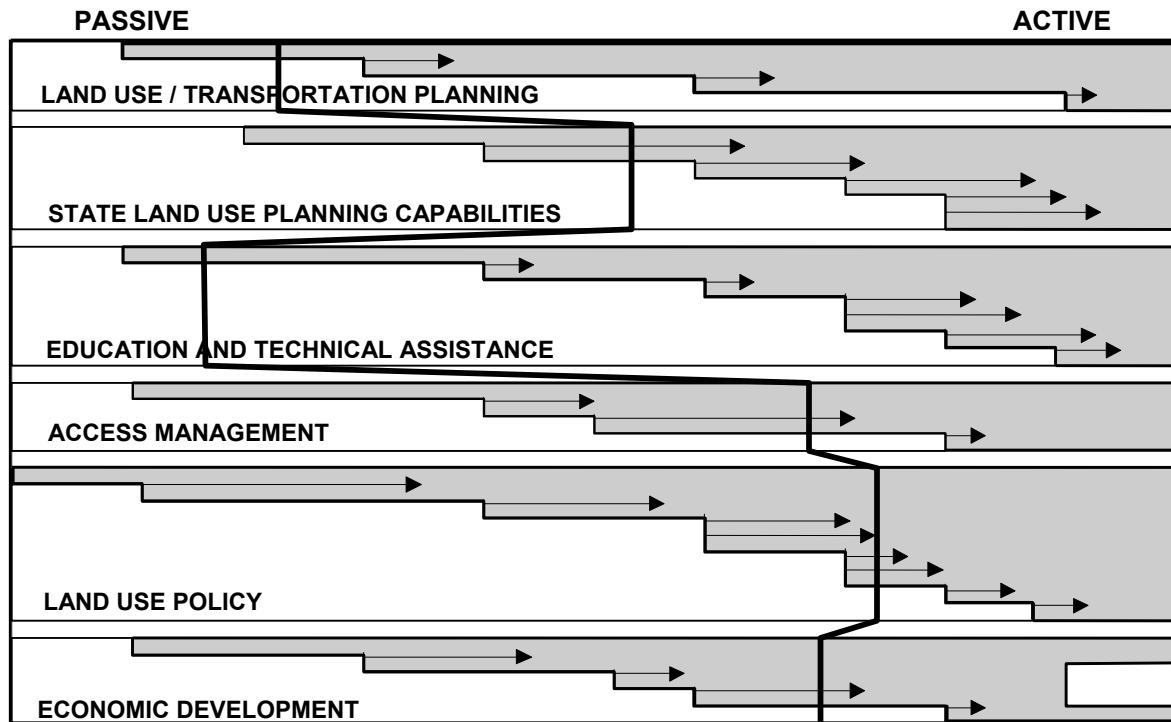
Federal Transportation Planning Regulations also require analysis of land use impacts of transportation investment decisions at the project level. These regulations represent the most far-reaching call for coordinated land use and transportation planning. However, these are very flexible as no specifications are given as to how to analyze land use impacts of transportation investments or how land use characteristics or development policies should be integrated into the transportation planning process.

The following is a series of suggestions for actions that the state should consider to improve its role in transportation and land use.

### 5.1. Self Assessment of Current Status

The first step that the state can take in the review of its land use and transportation policies is to conduct a self-assessment of existing policies for consistency. Existing state DOT programs activities and regulations should be reviewed to determine where they fit into Figure 2. The state can use this analysis to determine areas where they should be more active in coordination transportation and land use concerns. The state should also review the chart to determine if they need to add options to each of the categories on the chart or entire new categories based on emerging issues in Arizona.

A hypothetical example of this process is illustrated in Figure 3. The thick line plotted on the chart displays the present position of the state. A review of Figure 3 indicates that the level of activity in outreach and technical assistance appears to be inconsistent with other activities. This hypothetical state could rethink its role in providing outreach and technical assistance to local government in relation to its programs. Similarly, the state could organize oversight committees, conferences, and training programs to assist local agencies. With the implementation of these steps, the state could have a more consistent and balanced approach to land use actions.

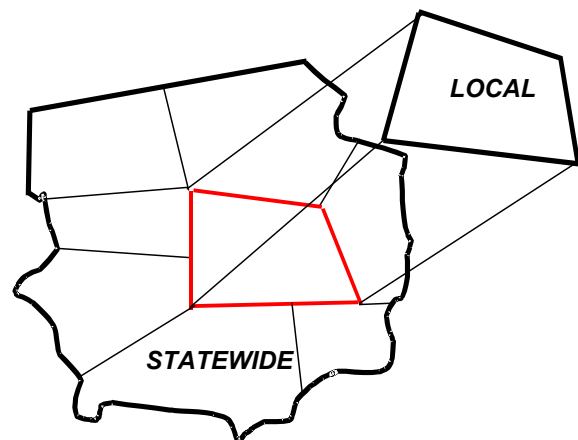


## 5.2. Coordination With Other Government Agencies

The key element of Figure 2 is the level of coordination between the state and other government agencies. This section provides an analysis of coordination between the state and local governments, and the state and federal agencies.

### 5.2.1. Coordination with Local Government

In most states land use decisions are made by local governments. Most state DOTs defer to local governments on land use issues, but may have review authority when the development involves access to or causes impacts on a state highway. By providing transportation facilities and services – be it through building highways, providing grants for local transportation improvements, or providing assistance to transit services – the state DOT affects land use patterns in many different ways. Similarly, all development and land use decisions will ultimately affect travel patterns and influence the decisions made by state transportation officials regarding project planning and programming. Transportation is irrevocably tied to land use and land development.



A critical issue the state must face is how the state deploys projects in relation to locally adopted plans. To what extent should the state promote transportation projects that may conflict with local plans? Some have argued that additions to highway capacity should not be made unless it follows the local plan. In the state of Maryland, infrastructure funds are directed to priority funding areas designated by local governments according to state criteria.<sup>22</sup> Funding programs are designed to provide for compact development and the state DOT follows the lead of local plans in designing its programs.

Even in states where the DOT feels it has no role in land use decisions, its staff members will find themselves heavily involved in land use concerns. These occur through the environmental review process, by issuing permits and by

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*“A critical issue the state must face is how the state deploys projects in relation with locally adopted plans”*

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deciding where, when and how to expand highway capacity. Who takes the lead in planning and identifying projects at the local level is a critical decision for a state DOT in defining land use policy. It may be that there are different procedures for different areas of the state. In areas with experienced local and regional planning agencies, they can easily take the lead in identification of projects for all levels of government. In other areas of the state with less local expertise, the state may have to take more of a lead role.

No matter who takes the lead role in land use decisions, a state DOT will need to be a participant if for no other reason than to protect the state’s investment in transportation services and facilities so they operate in an efficient manner.

### **5.2.2. Coordination with State, Federal and Tribal Agencies**

Many state and federal agencies and tribal governments take prominent roles in decisions that directly or indirectly affect land use in Arizona. Arizona is unique in that large amounts of land are under the direct jurisdiction of the state itself or a variety of federal agencies and tribal governments.

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*“The state DOT should consider how they interact with other state, federal and tribal agencies and actively explore methods to increase coordination and consistency between agencies.”*

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This situation requires a coordinated effort to deal with future growth in a logical way while minimizing harm to the environment, preserving sensitive lands, and encouraging economic development. To do so requires a high degree of coordination and agreement on common goals and approaches. The state DOT is only one of many agencies that should take part in these coordinated efforts.

One method to increase coordination between agencies is to establish a state land council that provides a forum for discussion of state land use issues and

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<sup>22</sup> “What you need to know about Smart Growth and Neighborhood Conservation” Maryland Office of Planning, May 1997.



works to establish consistency among agencies' programs. The success of this effort depends on the commitment of various state, federal and tribal agencies to working together on transportation and land use topics. Hot issues in one agency or area of the state may not be salient to others. The state DOT should consider how they interact with other state, federal and tribal agencies and actively explore methods to increase coordination and consistency between agencies.

### **5.2.3. Relationship with Private Sector**

A key question for the state to address is how they will work in partnerships with the private sector. Private sector developers seldom undertake projects that they feel are not financially viable. They react quickly to shifts in market demand and are generally open to change and innovation.

Improved communication with the private sector is essential for better coordination of land use and transportation. Clear guidelines and policies are needed to assist the private sector in making decisions. Uncertainty and project delays can cause severe financial problems and quick abandonment of projects. Good procedures are needed to involve the development community in transportation decisions. As in Florida, legal solutions may be more effective if developers are brought into the planning process early, instead of seeking ways to avoid the responsibilities of the process.

The changing nature of the population presents an opportunity for better coordination and cooperation with the private sector. Market potential for transit, walking, and bicycle travel will likely increase. The future population will be older and more diverse. Older residents require places to live that provide alternatives to an automobile dependant life style. People born outside the United States often have a greater propensity to use public transit. Both groups present markets for more compact development.

## **5.3. Education/Technical Assistance**

### **5.3.1. Improve State DOT Expertise**

Smart growth requires smart people who make smart decisions. The state DOT should examine the level of expertise in land use policy. If the state is to develop transportation systems with an awareness of land use, staff needs to be better informed about this relationship. Coordination with local and state agencies requires more information about the policies of these agencies. Coordination with the private sector requires more information about how they make decisions.

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*"Smart growth requires smart people who make smart decisions"*

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The state should examine the level of knowledge of their staff and determine how they can increase their expertise in land use. This should occur at all levels.

People who design individual projects or supervise the maintenance and operation of transportation systems should be involved. It is especially important that the state have expertise in real estate economics and development procedures to be successful.

At the local level, the state DOT needs to take a more active role in examining the land use transportation interaction. Each district office of the state needs ready access to expertise in land use and transportation interactions and active participation in local land use decisions. This may be best accomplished through district land use coordinators. Such a person or persons would work with local government and ADOT to tie land use and transportation closer together. They would know early on the concerns of local governments and use this information to improve transportation policies and projects.

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*“Each district office of the state DOT needs ready access to expertise in land use.... This may be best accomplished through district land use coordinators.”*

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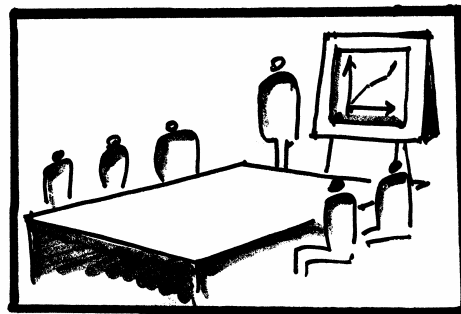
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To some extent this may require a change in the self-image of the organization. If the state is to become more sophisticated in how it deals with land use, staff needs to think of the agency in a different way. It is not just a highway builder anymore, but also a service agency that provides resources for smart use of land and wise investment of resources. Life is more complex if transportation decisions need to consider how they will affect future land use and transportation efficiency.

### **5.3.2. Technical Assistance from the State DOT**

A technical assistance and outreach program can be an effective way to increase the expertise of local governments and decision-makers. In some areas of the state, local and regional planning agencies are highly sophisticated and use state of the art techniques while other areas have fallen behind recent planning efforts and technologies.

The state can increase its involvement in land use issues by sponsoring conferences and training sessions. These programs are designed to make local government personnel more aware of good land use and transportation practices. For example, the state could sponsor local training sessions on access management for local government in order to convince local agencies of the need for better control of driveway entrances onto state highways. Typically, these training programs are run for one day and are held regionally to allow for attendance with a minimum of travel. Such programs may be offered by the state directly or by others with state sponsorship. The state DOT can be very effective as a catalyst for such programs if it actively encourages their development and promotion. Even if the



state feels that land use is entirely a local issue, training and conference programs can help local governments perform their jobs more effectively.

In addition, the state can develop guidebooks and technical assistance materials that are specifically directed to land use policies of local agencies. These materials can be used to help local government better understand best practices in planning and the interaction between transportation and land use. The materials can help create consistency in planning practice among local governments and be used to deliver information on emerging practices and techniques.<sup>23</sup>

#### 5.4. Access Management

Access management is one of the most direct ways in which transportation agencies and local governments can deal with adverse effects of development on transportation system performance. Careful planning of access in newly developing areas and good policy for driveway spacing and design can avoid many problems of congestion and safety that would otherwise occur. Good traffic flow occurs if turning movements on and off arterial roads are minimized and concentrated at places where they can be done safely. The state should examine how it manages access on roads under its jurisdiction and also develop methods to encourage and assist local governments in their access management.

Access management is a way for the state DOT to protect its investments in transportation by preventing actions that deteriorate the function of the facility.<sup>24</sup> State transportation facilities would be managed in such a way as to maximize their long-term benefits and to provide the greatest return on investment. In such a case the state could adopt strategies that protect investments from losing their value through poor land use and access policies.

For example, the department might pursue access management aggressively to protect facilities from losing their ability to provide mobility because of excessive access points. Similarly the department could engage in extensive interchange area planning to assure that traffic entering and exiting a major highway is not subject to extensive conflicts from interchange area developments. In such a case the department would develop rules for areas near interchanges as to types of land uses, complementary activities, and sharing of off road facilities.

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<sup>23</sup> Beimborn et al., "An Overview: Land Use and Economic Development in Statewide Transportation Planning", Report to the Federal Highway Administration, May 1999, Chapter 4.

<sup>24</sup> "Public Private Cooperation: Transportation Investment and Real Estate Development", Report to Wisconsin Department of Transportation by the Center for Urban Transportation Studies, University of Wisconsin-Milwaukee, June 1985.

## 5.5. Smart Growth

The most recent response to the problem of sprawl has been the adoption of 'smart growth' legislation.<sup>25</sup> This has occurred throughout the country and in places covering the political spectrum. Smart growth means different things to different places, but generally attempts to improve planning to avoid the adverse consequences of unplanned growth. These planning efforts are intended to continue to encourage growth, but with a better understanding of its long-term consequences. Smart growth legislation generally makes mandatory certain planning elements that were formerly optional for local government plans.

Smart growth conveys a new attitude towards planning that does not carry the stigma of imposing central control on land uses. A key feature of smart growth legislation is a strong reliance on local governments to make decisions. Ideally these are smart decisions that have a longer term view and weigh individual rights with the common good.

Smart growth legislation was first passed in more urbanized states on the east and west coasts with notable early efforts in Maryland and Oregon. Recently, states such as Tennessee and Wisconsin have adopted smart growth legislation. The Arizona legislature passed a series of laws to address smart growth, including the Arizona Preserve Initiative of 1996, the Growing Smarter Act of 1998, and the Growing Smarter Plus Act of 2000. These laws strengthen planning requirements at the local level and permit the use of tools such as purchase of development rights to protect critical lands. They also allow municipalities to set infrastructure service boundaries and indicate that municipalities may not annex an area unless they have a plan in place to provide the infrastructure within 10 years.<sup>26</sup>

The legislation is still new in the state and much of it remains to be implemented. Several communities have gone through plan ratification by voters and many others are in the process of developing plans that conform to the legislation. Time will tell if the legislation will make a difference in how Arizona grows and develops.

A critical question sometimes left out of smart growth legislation is what is the state required to do with smart growth. In some states, the legislation is silent about state agencies and programs, while in other places the state is required to conform to local plans. For example, the Maryland smart growth legislative package restricts most state infrastructure funding, economic development, housing and other program dollars to Priority Funding Areas<sup>27</sup> designated by local governments. Smart growth policy objectives are integrated into the transportation system through the planning process. This may mean that

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<sup>25</sup> "Planning Communities for the 21<sup>st</sup> Century". A Report of the American Planning Association, December 1999.

<sup>26</sup> "Growth Management and Open Space Protection in Arizona: Current Tools and Progress". Issues in Brief, the Morrison Institute, Arizona state University, June 2001.

<sup>27</sup> Ibid., p. 6.

highway expansion does not take place outside of the priority funding areas if it will lead to sprawl elsewhere.

It is obvious that transportation planning needs to be an integral part of smart growth at the local level. The state DOT needs to decide how they will participate in local smart growth planning and how state projects complement the implementation of local plans.

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*“The state DOT needs to decide how they will participate in local smart growth planning and how state projects complement the implementation of local plans.”*

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## 5.6. Land Use Programs

Smart growth provides a general framework for thinking about land use programs. Other practices can be used as individual measures to increase the tie between land use and transportation. These include improvement of connectivity between developments, consideration of transit corridor districts, and interchange area planning procedures. All provide common sense ways to avoid long term traffic congestion problems associated with growth. A rapidly growing state such as Arizona can use these steps to greatly reduce future problems.

### 5.6.1. Secondary Impact Analysis

The state might consider an extended environmental review of the land use impacts of transportation projects. For example, Wisconsin DOT developed a technical reference guidance document that its districts use to determine a project’s potential to change land development patterns.<sup>28</sup> The document provides general information on land use planning, development regulation, and the relationship between transportation investments and land development patterns. The document provides a guide for evaluating land use impacts in the NEPA process.

The framework provides a means to assess impacts for potentially significant projects. Analysis of the indirect and cumulative effects on land development at the project level is different from local land use planning. Local land use planning merely studies and develops local goals and community vision, while project level analysis focuses on how the project alternatives affect local land use and land use plans. Local jurisdictions and consultants in the transportation planning process follow the guidelines provided in the reference guide.

### 5.6.2. Connectivity

An important topic for state and local governments is how they provide connectivity between adjacent developments and properties. Good practice includes providing multiple entrances and exists for residential and commercial

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<sup>28</sup> “Indirect and Cumulative Effects Analysis for Project-Induced Land Development.” Technical Reference Guidance Document, Wisconsin Department of Transportation. p. I-1.

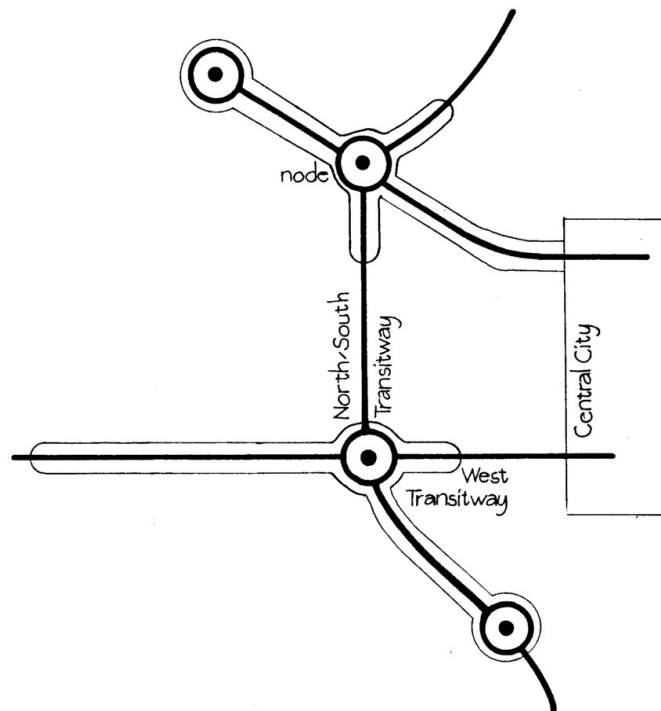
developments to permit internal circulation and movement within neighborhoods without the need to use surrounding arterial roadways. This can reduce the need for excessive travel for short trips and lead to more efficient travel over the overall network. This implies limited use of cul du sacs and multiple ways in and out of each individual development. Guidelines for neighborhood connectivity could be developed as a tool for local government to use in the planning of growth areas and neighborhoods.

Improved connectivity within neighborhoods will also make it easier to walk or use bicycles for travel since those trips can be made without the need to travel along busy arterial highways. Access to transit service is also enhanced since walk paths to stops are direct and do not require circuitous travel.

### 5.6.3. Transit Corridor Districts

A transit corridor district is an area where transit service will be provided in the future and a place where land uses are arranged to facilitate transit services.<sup>29</sup>

They include a mixture of land uses that relate well to transit and provide a street and pathway pattern that facilitates transit use, as well as bicycling and walking. Transit services would likely be bus-based with provisions to be upgraded to other technologies at a later date. To be effective they should be predesignated as part of a regional transportation planning effort. Early location and designation of the corridors is essential so that subsequent land use decisions can conform to the expected pattern of uses. They form the basis for the development of mixed use, pedestrian friendly places and provide a way for private developers to serve emerging residential and commercial markets.

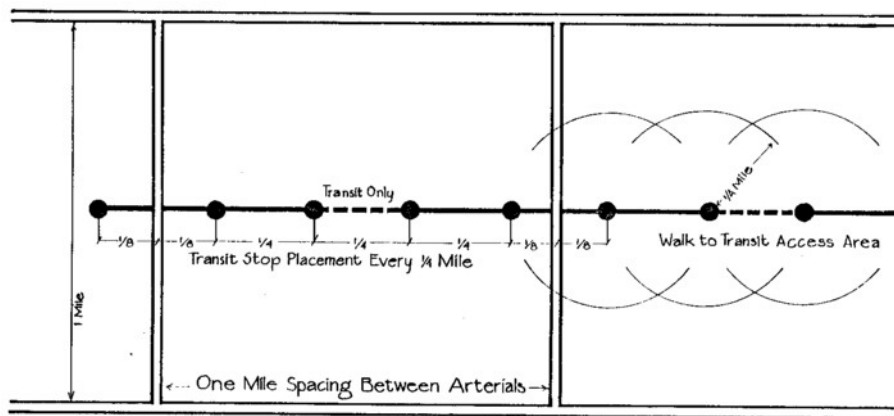


Ideally, transit corridor districts include the physical separation of transit service and primary auto-oriented travel. Transit corridors are located parallel to major arterials but within areas zoned for mixed use neighborhoods and transit-oriented land uses. Street patterns could be arranged to facilitate walking and transit stop access with a limited control of through auto movement along the transit corridor. Advance knowledge of where transit services will be provided will permit private sector developers to utilize property in an efficient way to take advantage

<sup>29</sup> For more information on this topic see "Guidelines for Transit Sensitive Land Use Design" Report to Federal Transit Administration by the Center for Urban Transportation Studies at the University of Wisconsin-Milwaukee, July 1991, also see TRB [Record #xxx](#)

of the alternative transportation choices. Arterial access management is an important complementary policy that can help to focus activity centers, such as commercial development, near transit stops. Transit corridor districts may have different zoning provisions that permit more flexibility by developers. They can create a win-win situation for private development and transportation agencies as both benefit through more logical linkages between land use and transportation.

### Transit Corridor District Concept



Arizona may be particularly suited to this concept. Rapid growth, a well-developed grid system of arterial highways, and a diverse and aging population make it an ideal place to use the concept. Success depends upon coordination between regional planning agencies, local government, and the state DOT. The state should consider this concept as a way to increase choices in both land use and transportation services. The state must work with local planning agencies to explain the process and should consider the development of prototype designs and model code revisions.

#### 5.6.4. Interchange Area Planning and Deployment Strategies

Highway interchange areas are prime sites for development. They attract commercial and employment activity and become the focus for substantial growth and development. If this growth is poorly planned, the interchange area becomes a place with excessive traffic conflicts and poor connection between properties and developments. The state should produce guidelines on issues of interconnection, access spacing, shared driveways, transit service location pedestrian movement, and internal circulation. These guidelines set the stage and ground rules for all that follows and help to avoid haphazard interchange area developments.

## 6. Conclusions

Land use changes are the result of many small decisions and occur incrementally over time. What may appear to be minor decisions at the time will accumulate to result in major changes in the landscape with unintended consequences. For all practical purposes, these changes are permanent and irreversible. Because of its fast growth, Arizona residents see an accelerated version of this process and even relatively new residents of Arizona can see dramatic changes in the landscape as they first saw it when they arrived in the state. Land use changes occur continuously as communities evolve and grow over time and do not stop at any point in the future.

By contrast, planning and land use policy efforts typically focus on a particular date or milestone in the future. They involve a significant effort for a short time and then are put to rest until updated some years later. These different perspectives make it difficult to implement meaningful change over time and to keep policies in place for the long run. Plans can be perishable commodities that are soon ignored or placed aside. To sustain a long term change in direction requires a change in attitudes and awareness by those who will work with them over the long run. Stable policies have to make sense to many constituencies to survive changes in administration that will occur over time.

Transportation and land use will become an increasingly important issue in Arizona. Rapid growth in the future and limited transportation resources means that the state DOT will have to take a more active role in land use decisions and policies. Furthermore smart growth initiatives will require the state DOT to consider how it interacts with local communities and other agencies. Critical questions the state needs to address are the following:

- ◆ How actively should the state participate in local land use and transportation planning decisions?
- ◆ What does the state do about projects that do not complement the implementation of local land use plans?
- ◆ How does the state DOT interact with other state, federal and tribal agencies on land use issues?
- ◆ How does the state increase its level of expertise in land use issues at the central office level as well as in the district offices?
- ◆ What level of technical assistance does the state provide to local governments in land use issues?
- ◆ How does the state balance private interests with public interests in land use and transportation decisions?
- ◆ What can the state do to increase the management of access on the state highway system?



- ◆ How does the state protect its investment in facilities to prevent their functional obsolescence?
- ◆ How can the state help in providing good connectivity between neighborhoods and developments?
- ◆ What can be done to provide a framework for transit oriented, compact development in growing areas of the state?
- ◆ How should the state manage the development of activities around the interchanges on the state highway system?

How Arizona deals with these questions during development of the long range transportation plan, as well as during subsequent implementation of the plan, will have an impact on many related concerns of importance to the State such as preservation of transportation system investments, economic vitality, resource conservation, and overall customer satisfaction with the functionality of the transportation system.

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# **Security Considerations in Long-Range Transportation Planning**

# SECURITY CONSIDERATIONS IN LONG-RANGE TRANSPORTATION PLANNING: A WHITE PAPER FOR THE ARIZONA DEPARTMENT OF TRANSPORTATION

By  
Steven E. Polzin, P.E. Ph.D.

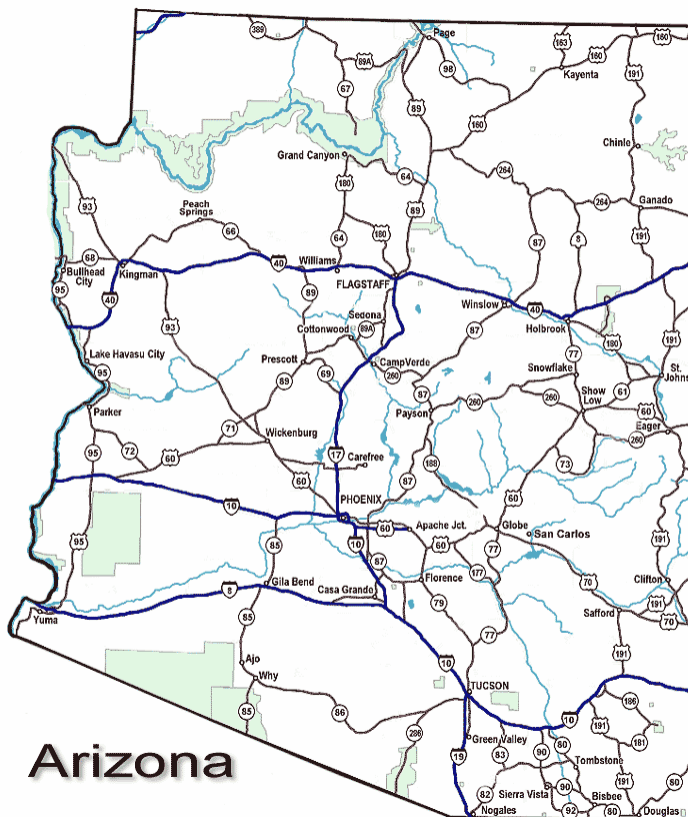
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## Introduction

This paper explores the implications of enhanced security concerns on state department of transportation long-range transportation planning activities. The Arizona Department of Transportation, (ADOT), in the process of updating its long-range plan, has recognized that security concerns will significantly influence how transportation facilities and services are provided. Hence, via this white paper, ADOT is exploring possible implications on long-range planning. The paper is an exploratory look at how security concerns may be integrated into long-range planning activities. Over the next several years, security considerations will most probably result in a multitude of changes in how transportation is planned, designed, implemented, and operated. Transportation goals, planning processes, databases, analytical tools, and organizational structures will change due to security concerns. This paper is intended to seed that discussion and facilitate that process of change.

## Transportation and Security

A secure transportation system is critical to overall national security from terrorism. Groups or individuals motivated to terrorize or injure people or the economy may well have transportation facilities as a target or a tool. Most assuredly, they would have a transportation element in an overall plan. Thus, securing the transportation system is a critical consideration in overall security planning.

Terrorists may be motivated to disrupt the economy. Transportation infrastructure is critical to the functioning of the economy. Transportation activities comprise 12 percent of the gross domestic economy, and virtually all of the economy is contingent on a functioning transportation system. Disruption to critical links in the transportation system provides an opportunity to cause serious economic harm. Thus, transportation facilities may be targets of terrorists intending to harm the economy.

Terrorists may be motivated to cause personal injury to concentrations of people. Transportation facilities often provide anonymous gathering places for large numbers of individuals. Planes, trains, buses, terminal facilities, and pedestrian plazas have been terrorist targets. Thus, transportation facilities as gathering places for large groups of people may be targets of terrorists seeking to kill or injure significant numbers of individuals.

Terrorists may be motivated to strike at symbolic targets in an effort to harm a group or organization of people. High profile transportation facilities may be emotionally appealing targets for terrorism. The Golden Gate Bridge, the LA Airport, and other high profile transportation facilities have been mentioned as possible targets due to the fact that damaging these facilities would have impacts beyond the personal and economic consequences. Thus, high profile transportation facilities may be targets of terrorism.

Terrorists need to deliver the people, munitions, explosives, biological agents, or other destructive elements in their initiatives to terrorize. Transportation is explicitly an element of delivering terror. Be it airplanes, as in the case of September 11, 2001; trucks, as in the case of the Oklahoma federal building bombing and the 1993 World Trade Center bombing, or personal and freight vehicles that move the people and materials of terrorism around, transportation vehicles and facilities are critical elements in delivering terror.

Finally, as transportation is critical to the mobility of all people, including individuals who inflict terror and jeopardize security, transportation operating and regulatory agencies have opportunities and responsibilities to oversee various aspects of person movement and licensure. This includes involvement in securing borders, licensing vehicle operators, licensing vehicles, and enforcing various other laws regulating the safe use of vehicles and the transportation system.

Collectively, the transportation sector is intimately involved in the security of our society and, in many respects, will be a front-line area of focus in enhancing security. The future of transportation will be very much influenced by security considerations.

*Transportation requires security because it:*

- *Is a critical element of the economy*
- *Is a gathering place for groups of people*
- *Has symbolic and emotional importance*
- *Provides a delivery means for people and products of terrorism*
- *Includes institutions with licensing and enforcement responsibilities*

## Security Risk

In its simplest terms, security risk might be expressed as a mathematical function. The security risk is a product of the probability of an incident attempt times the vulnerability of the target times the damage costs of a successful breach of security:

$$\text{Security Risk} = \text{Probability of Incident Attempt} \times \text{Vulnerability} \times \text{Damage}$$

Each of these terms suggests something about the nature of security risks to the transportation sector and the potential consequences of ongoing security concerns. Historically, domestic security concerns have been modest as a result of the fact that the probability of an incident was believed to be so dramatically small that the extent of vulnerability and the size of the potential damage had been relatively unimportant. However, in the post September 11<sup>th</sup> era, the probability of an incident attempt is far greater than previously appreciated by the vast majority of the public, thus resulting in the security risk being far greater than heretofore acknowledged. Additionally, the magnitude of the potential damage from an incident is now recognized as far higher than previously perceived. The extraordinary human and monetary consequence of the September 11<sup>th</sup> incident increased by orders of magnitude the perceived size of the possible damages from an incident of terrorism. Subsequent expert and media scenarios of increasingly sophisticated and dangerous tools of terrorism, including biological and chemical agents as well as the use of ever more powerful explosives strategically placed, has increased the commonly held perception of security risk being for virtually all public and private sector entities in the United States.

Although the above calculation could be applied to individual services and facilities, it can also be applied at the systems level where it would suggest that the security risk is now far greater, and, accordingly, should receive more attention and resources to aid in more fully diagnosing and taking other steps to reduce one or more of the factors -- probability of

incident attempt, vulnerability or damage. Both the freshness of the memories of September 11<sup>th</sup> and the empirical reality of this event on the cumulative calculation of security risk will result in heightened attention for a period of time, certainly several years, even in the absence of subsequent events. If significant subsequent terrorist events occur that involve transportation services or infrastructure, then the corresponding values in the above equation will continue to increase the measure of security risk and, most assuredly, the investment in enhancing the security of transportation.

### **What Does Increased Security Risk Mean?**

Within days of the tragedy of the September 11<sup>th</sup> terrorist incidents, speculation began in the media among security and transportation experts and among the general public regarding the consequences of these incidents on America's mobility. The speculation has run the gamut, from predicting the end of skyscraper construction and the subsequent decline in urban densities, to anticipating or advocating new infrastructure investments such as high-speed rail as alternatives to air travel. In the months since the incident, there has been a flurry of responses including military personnel policing airports, organizations and businesses pulling sensitive information off web sites that could have aided terrorists in planning attacks, and the U.S. Department of Transportation establishing a process whereby all transportation employees will go through a screening and verification process. A multitude of other activities are in various phases of planning and implementation, and a significant effort is appropriately being invested in careful analysis and planning for subsequent steps in the overall plan to improve security. Old reports are being dusted off, new reports are being written, task forces are being formed, and training initiatives are being provided. Early action steps are already being identified and implemented while other actions will require considerable more evaluation before prudent actions can be determined.

The remainder of this paper explores how heightened security concerns will impact the planning, design, implementation and operation of transportation infrastructure and services and how these changes then might influence how long-range transportation planning is carried out -- specifically, how the Arizona Department of Transportation may be impacted and how the impacts of heightened security sensitivity may result in changes in how long-range planning is conducted. Evaluation criteria for project programming are likely to change and costs for various transportation investments may change as a result of different design standards that enable enhanced security. Intelligent Transportation System (ITS) investments may have security roles and incident response rolls that may change how we design and specify these systems. Mode choice behaviors may change influencing the overall demand for various travel options. The era of placing parking lots under elevated freeway sections may end, and the processes of issuing driver licenses and vehicle titles may change as security considerations influence the data collection and screening steps. The goal of this paper is not to identify or prescribe all the actions that will need to be taken, but rather to focus on how the changes that do occur will impact how one might go about doing long-range planning.

The response to terrorism is not restricted to the state departments of transportation. Security issues permeate all levels of government and all aspects of planning and delivery of services and infrastructure. The private sector also is significantly impacted. Security will impacts day-to-day operations, mid-term planning and programming and long-range planning activities.

The following section outlines some thoughts on how security concerns might influence transportation. The intention is to speculate on the full range of possible impacts and to

subsequently sort and classify them in a manner that enables one to systematically explore what this might mean in terms of transportation planning. Subsequent sections explore the implication on the long-range planning process.

## **The Impacts of Security Concerns on Transportation**

The September 11<sup>th</sup> incident created a financial crisis for the airline industry; government involvement will inevitably change our perception of a mode that heretofore was generally regarded as user supported. Regardless of who pays, the long-term cost of air travel is likely to go up, due to greater security costs, higher risk costs, and perhaps fewer economies of scale. Time costs of air travel may also go up as security clearances slow boarding. And, somewhat unique to air travel, there may be an increase in those who have a mode-choice-altering fear of flying. How do these changes filter into our transportation planning activities? Should mode choice coefficients or the time and money cost estimates of various modes be altered for future planning studies? Has the steeply-sloped curve of growing air travel demand been permanently altered? Can technology and procedures ultimately provide needed security without significant time penalties? Does the willingness of the federal government to make a significant financial contribution to the airline industry render subsequent subsidies to Amtrak or high-speed rail more palatable?

After a decade of preaching multimodalism and modal integration, do we need to rethink those plans for remote airline check-in counters at downtown rail transit stations? Is the convenience of intermodal transfer offset by the security risk of larger concentrations of passengers and the complications of security screening to the highest prevailing standard of the associated modes? Are all modes of public travel inherently more attractive to terrorist attention and hence subject to higher security costs? Some have argued that investment in alternatives such as rail provides a necessary contingency -- do we now justify investments in these alternatives by highly valuing this contingency potential in our resource programming decisions?

Many have noted that transportation's importance to the economy was underscored by the terrorists' actions, and hence, the public may be more willing to increase the investment in our transportation system. Yet, security concerns will increase competition for funds in the near term and may significantly impact the cost of transportation infrastructure and services over time.

Will there be more subtle impacts in personal activity schedules and behaviors that will impact transportation? Some suggest that there is a renewed focus on the family and a tendency to stay closer to home. Others have speculated on a fear of traveling to high profile locations. Among the more subtle impacts, perhaps road rage will be lessened, as Americans draw closer together and become more considerate of others. Within an hour of the first terrorists' actions on September 11<sup>th</sup>, traveler behavior in response to security threats changed remarkably from passive to active roles in responding to security incidents.

Intelligent transportation system investments are now seen as an important tool in responding to terrorist incidents and their design is taking into consideration the possible role in disaster evacuation. Physical locations of transportation infrastructure are receiving more attention, with parking locations being scrutinized from the perspective of the opportunity parking provides for staging an attack on adjacent facilities. Table 1 outlines the types of security threats that have been contemplated as possibly impacting transportation facilities and



services. This same source cites a 1995 intentional derailing of a train in Arizona as an example of a security incident probably caused “by right-wing extremists or a former railroad employee.”

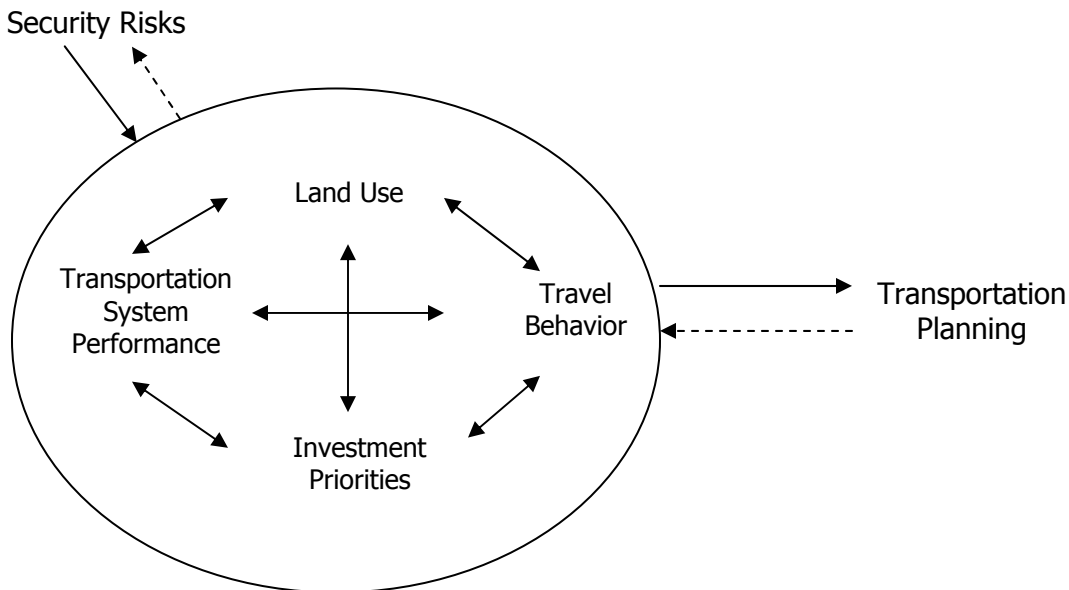
Table 1: Scenarios Considered in the U.S. DOT Vulnerability Assessment

Physical Attacks	
<ul style="list-style-type: none"> <li>• Car bomb at bridge approach</li> <li>• Series of small explosives on highway bridge</li> <li>• Single small explosive on highway bridge</li> <li>• Single small explosive in highway tunnel</li> <li>• Car bomb in highway tunnel</li> <li>• Series of car bombs on adjacent bridges or tunnels</li> <li>• Bomb(s) detonated at pipeline compressor stations</li> <li>• Bomb detonated at pipeline storage facility</li> <li>• Bomb detonated on pipeline segment</li> <li>• Simultaneous attacks on ports</li> <li>• Terrorist bombing of waterfront pavilion</li> <li>• Container vessel fire at marine terminal</li> <li>• Ramming of railroad bridge by maritime vessel</li> </ul>	<ul style="list-style-type: none"> <li>• Attack on passenger vessel in port</li> <li>• Shooting in rail station</li> <li>• Vehicle bomb adjacent to rail station</li> <li>• Bombing of airport transit station</li> <li>• Bombing of underwater transit tunnel</li> <li>• Bus bombing</li> <li>• Deliberate blocking of highway-rail grade crossing</li> <li>• Terrorist bombing of rail tunnel</li> <li>• Bomb detonated on train in rail station</li> <li>• Vandalism of track structure and signal system</li> <li>• Terrorist bombing of rail bridge</li> <li>• Explosives attack on multiple rail bridges</li> <li>• Explosive in cargo of passenger aircraft</li> </ul>
Biological Attacks	
<ul style="list-style-type: none"> <li>• Biological release in multiple subway stations</li> <li>• Anthrax release from freight ship</li> </ul>	<ul style="list-style-type: none"> <li>• Anthrax release in transit station</li> <li>• Anthrax release on passenger train</li> </ul>
Chemical Attacks	
<ul style="list-style-type: none"> <li>• Sarin release in multiple subway stations</li> </ul>	<ul style="list-style-type: none"> <li>• Physical attack on railcar carrying toxics</li> </ul>
Cyber and C3 Attacks	
<ul style="list-style-type: none"> <li>• Cyber attack on highway traffic control system</li> <li>• Cyber attack on pipeline control system</li> <li>• Attack on port power/telecommunications</li> </ul>	<ul style="list-style-type: none"> <li>• Sabotage of train control system</li> <li>• Tampering with rail signals</li> <li>• Cyber attack on train control center</li> </ul>

Source: National Research Council, *Improving Surface Transportation Security, A Research and Development Strategy*, Washington D.C: National Academy Press, 1999; originally in U.S. DOT, *Surface Transportation Vulnerability Assessment*, Final Report, Washington D.C. May, 1998.

It may be useful to explore the implications of security threats on transportation planning by reflecting on a simplistic model. Figure 1 outlines such a model, where security concerns influence land use, travel behavior, public investment priorities, and transportation system performance. In each category, impacts can be long or short range. These changes may create a need to change transportation planning activities. Changes in our planning subsequently feed back to influence these four factors and thus, the level of security risk may be impacted as changes influence the probability of an incident attempt, the vulnerability, or the damage.

Figure 1 Conceptual Model of Impacts of Security Risks on Transportation Planning



Each of the four factors is discussed below with examples of how they may change as a result of security risks.

**Land Use** -- Individuals have speculated on a variety of land use implications, ranging from an increase in employment dispersion and sprawl to a renewed focus on the importance of the city. Although signature high rises may not be a growth market, there is little reason to anticipate meaningful land use changes in the short term. The fixed nature of land use and capital intensive supporting infrastructure dampens any rapid land use changes even if there were strong pressures to make changes. According to participants in the recent Urban Land Institute's Global Mayors Forum, the September 11<sup>th</sup> terrorist attacks have sharpened the focus of municipal officials, both nationally and abroad, on the need to sustain urban revitalization efforts and enhance community livability. The participants concurred that although the possibility exists that the attacks could drive some people out of urban areas, the reaction of urban residents so far has resulted in an "overwhelming celebration" of cities. Other planners have postulated that the economic impacts will slow retirement-driven migration patterns as well as growth in tourism intensive economies. Subsequent reports from New York real estate analysts suggest that there will be some dispersion from Lower Manhattan to other locations in the near term. This appears to reflect a variety of factors including security concerns but other factors as well. There does seem to be some reinforcement of the concept of a given firm having multiple locations to enable it to have redundancy in case of disasters.

The complex set of factors that govern location choice will make it difficult to determine the significance of security risks in location decisions and subsequent land use patterns. Discerning security considerations from factors such as the ongoing shift to service and information industries and the influence of improved communications on location choice may favor dispersion of activities regardless of security concerns. If there were to be multiple

future terrorist incidents concentrated in highly urban areas or other specific locations, this could result in land use responses becoming more significant over time.

In Arizona one would not currently anticipate security concerns to induce changes in land use patterns that would influence long-range planning initiatives. Although one might speculate that heightened security concerns may reinforce demographic shifts to lower density smaller areas, there is currently no empirical basis for this expectation. There is no reason to expect that security concerns will impact migration to or from Arizona or the distribution of population within Arizona at this time.

**Travel Behavior** -- One can speculate on how security risks may impact each of the traditional four elements of travel behavior that transportation planners typically consider: trip generation, trip distribution, mode choice, and route assignment. As in the case of land use location choices, travel behavior is complex behavior influenced by a host of factors. The cumulative experiences and perceptions of travelers will influence travel behavior; thus, the perception of security risk as influenced by security incidents and perceptions of security levels for various travel options will influence individuals' travel decisions.

*Travel Behavior:*

- *Trip Generation*
- *Trip distribution*
- *Mode Choice*
- *Route Assignment*

**Trip Generation** -- After September 11<sup>th</sup>, trip making declined as people chose to forgo certain trips. This behavior was particularly apparent for long distance business and personal trips. There is speculation that a proportion of the general public will remain less willing to fly than they were prior to September 11<sup>th</sup>. Some may substitute auto or rail travel, but some others will simply forgo the activity. On the business side, there is likely to be some mode shift but also some occasion for other forms of communication to substitute for travel. The September 11<sup>th</sup> tragedy is likely to enhance the use of evolving telecommunications capabilities and result in some activities being carried out by phone and other electronic communications means. The information we have on changing trip generation is based on the single extraordinary September 11<sup>th</sup> event and is complicated by the economic consequences of that event and the underlying slowing of the economy. Certain travel demand may be postponed in time while other travel may be a net loss. The empirical data that is currently being gathered suggests that the travel industry is recovering from the consequence of September 11<sup>th</sup>. It is premature to predict how security risks will impact long-term long-distance trip generation directly. Indirectly, changes in travel costs and other factors as a result of security considerations could also impact trip generation levels. As shown in Figure 2, the share of total person travel that is classified as urban (less than 100 miles from home) is the vast majority of all travel nationwide, approximately 82 percent. Arguably, the fear of security risks has had very modest, if any, direct impacts on overall local trip making beyond the immediate physical area of an incident and the immediate aftermath of an incident. Only with sustained security incidents is it likely that local trip making rates would be measurably impacted.

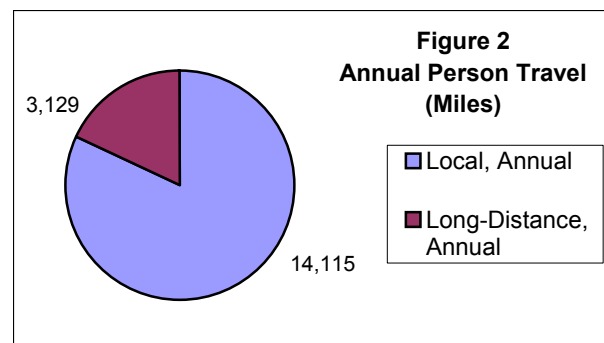
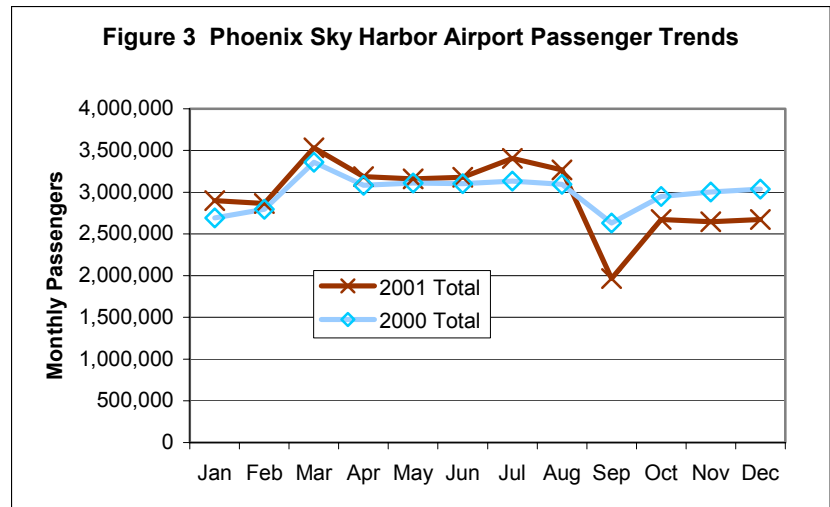


Figure 3 indicates travel activity at Phoenix Sky Harbor Airport. As this graphic indicates, air travel levels have recovered from the immediate post September 11<sup>th</sup> levels. The remaining discrepancy in travel levels from pre-September levels is most probably attributable to a number of factors from security related fears to economic conditions to declining air service frequency to longer travel times through airports as a result of security precautions.



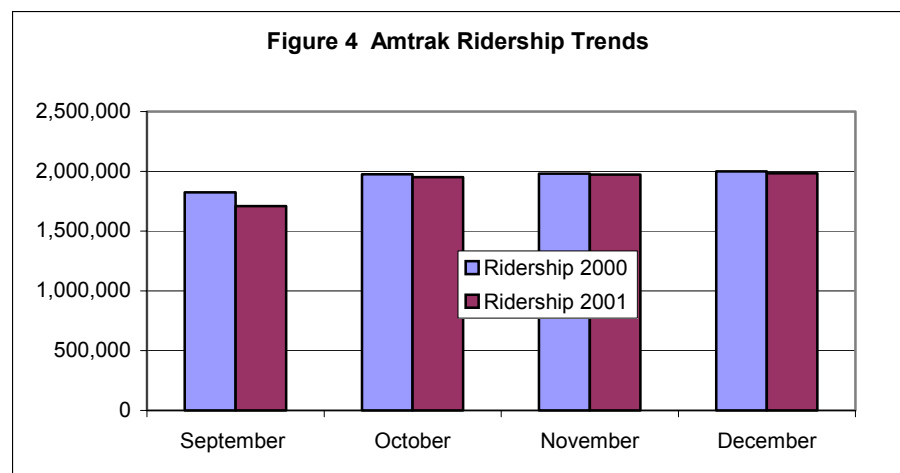
**TRIP DISTRIBUTION** -- Another possible significant change resulting from September 11<sup>th</sup> may be altered trip destinations. Individual travel location choices might be modestly altered. As people refocus their priorities, some may value time with family more highly and choose to minimize lengthy commutes to distant job sites. Conversely, others have argued that the push toward decentralized urban areas may result in greater sprawl, meaning longer commute trips for many. Independent of the effects of the slowing economy, work commitments and local urban travel activities are likely to remain unaffected. There may be situations where a high profile location and presumed attractive terrorist target may be avoided by some travelers. For example, following September 11<sup>th</sup>, there were warnings that the Golden Gate Bridge may be a target of terrorists. This type of attention may result in altered trip destinations with people substituting alternative destinations to avoid certain routes, or trip paths. Other travelers may be more reluctant to use various facilities that are perceived to be at risk or susceptible to significant damage if attacked. For example, some travelers may avoid tunnels and bridges. An example of changes in Trip Distribution includes dramatic falloff in retail sales at downtown Chicago buildings, such as the Sears Tower, when security measures made it more difficult to access interior businesses, such as restaurants and service outlets.

The largest prospect for change in trip distribution again involves those longer distance trips - specifically, trips that might involve air travel. In this regard, both personal and business trips are likely to be affected. Some individuals will choose vacation locations that do not require air travel, and other locations that are perceived as unsafe or prone to security bottlenecks, may be avoided. Travelers have long avoided international hot spots, and, if sustained terrorist activities result in concentrations of incidents in certain locations, then those locations are likely to be avoided. In a more general sense, travelers may seek to avoid crowded or high profile locations or events in fear that these could be targets for terrorists. At a national scale, Arizona does not have travel destinations that are likely to become compelling terrorist targets. Only with a sustained significantly higher frequency of incidents are travelers likely to meaningfully alter trip destinations as a result of the fear of terrorist incidents.

**Mode Choice** -- Mode choice changes as a result of security concerns are possible due to fears that arise from terrorist incidents or the prospects of them and as an indirect result of changes in the performance of modes due to security induced changes. The most obvious example is the impact on airline travel. Initially fears of flying altered long-distance trip-making mode choices for some people and, over time, change in the time or money cost of air travel may continue to impact air travel choice. To the extent that there is a fear that vehicles such as planes or buses could be hijacked and used in a terrorist incident or that mass mode vehicles or station locations are perceived as attractive targets with crowds of people, these modes may be avoided by some travelers. It would appear that public modes offer the opportunity for terrorists to both remain anonymous and to impact groups of people; thus, one might expect individual vehicles are less likely to be targets of terrorism. Currently there is no empirical or anecdotal evidence to indicate the extent to which mode choice behavior will be altered. There is no evidence to indicate the extent to which travelers removed in time and space would react to a terrorist incident. Would travelers in Phoenix be less likely to use the bus if there had been a bus bombing in New York three days ago, or three months ago, or three years ago? What if the incident were in Mesa or in Phoenix? At this point in time, planners do not know what types of incidents or frequency of incidents would be necessary to change travel behaviors that are reflected in long-range transportation modeling.

As shown in Figure 3, air travel has been disproportionately impacted by the September 11<sup>th</sup> attack -- however, one can only speculate with limited data regarding how much of this decline in air travel was accommodated by travel on other modes. Amtrak, as shown in Figure 4, was not as seriously impacted, but there is little evidence that much air travel shifted to intercity rail. Some speculate that there was a shift to auto travel. Again, mode choice changes appear to be more apparent for long distance trips. Local travel is predominantly auto travel, and the terrorist incident did nothing to discourage the individual auto mode choice.

Indirect impacts to mode choice are also likely as a result of security risks. Significant and highly visible changes to air travel security and perhaps less visible changes in security precautions for other modes of collective travel could result in mode choice differences. The most obvious impact will be the time and dollar cost of providing the security for travel by public carriers. Currently airport arrival time increases are variously perceived to be in the vicinity of an hour (more than previously required). Intercity bus and rail security also has increased, but service times are not perceived to have been impacted. Air travel security changes are continuing and are expected to evolve over the next several years as strategies and technologies are put in place. A \$2.50 per flight segment passenger security surcharge has been introduced for heightened airport security.



Other estimates and strategies could result in a significantly higher per trip increase in the cost of delivering air travel. The magnitude of that cost and how it is passed on to travelers and non-travelers will impact the extent to which security costs influence mode choice for air travel. Time penalties for security enforcement also can influence mode choice as they may impact the comparative attractiveness of air travel versus alternatives. In many locations, an additional hour per air trip for check-in could be enough to encourage the traveler to choose an alternative such as driving or perhaps rail travel in corridors where it is available. The long distance nature of air travel to and from Arizona is such that few time-competitive alternatives to air travel exist; hence, the time costs of security are less likely to influence mode choice significantly.

Security incidents such as evacuations of terminals and cancellations of flights as a result of suspicious circumstances can, over time, result in poorer reliability of air travel and hence a greater reluctance of travelers to use it. However, air travel nationally carries approximately 100 times as many passenger miles as Amtrak; thus, the absence of competitive alternatives will dampen the impact of security concerns on air travel mode share.<sup>1</sup>

Beyond long-distance travel, security considerations may impact local travel as well. Factors that may affect more localized urban travel include changes in security procedures that affect public transit and parking facilities. In several areas of the country, parking facilities have been closed or security enhanced in order to restrict access. The fear that vehicles loaded with explosives could damage adjacent facilities or gatherings have resulted in changes in parking policy and locations in numerous areas. The 1993 World Trade Center bombing and the 1995 Oklahoma Federal Building bombing both involved trucks parked in locations that enabled their explosive contents to cause tremendous damage to the respective facilities.<sup>2</sup> To the extent that security concerns impede access by car or truck to various locations or result in search delays for entering vehicles, travel behavior could be impacted. Greater walk access from parking to the ultimate destination, higher-priced parking as accessible supplies dwindle, or other changes imposed as a result of security concerns could dampen the relative appeal of personal auto travel.

Finally, to the extent that subsequent terrorist activities create a fear of group travel, there is the prospect that public modes of group travel could be impacted. In Israel, repeated terrorist incidents on public buses have reportedly altered the willingness of some individuals to use public transportation. Although the prospects of such perceptions developing in the U.S. are not imminent at this time, they could impact mode choice.

**Trip Assignment** - Trip assignment refers to the actual decisions on the trip route once the location and mode have been determined. Security concerns may result in some changes in trip assignment behavior. Individuals may choose to avoid routes/facilities that they feel

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<sup>1</sup> Bureau of Transportation Statistics, *Pocket Guide to Transportation*, Table 9, Page 13.

<sup>2</sup> 1993, Feb. 26, New York City: bomb exploded in basement garage of World Trade Center; killing six and injuring at least 1,040 others. Six Middle Eastern men were later convicted. They claimed to be retaliating against U.S. support for the Israeli government.

1995, April 19, Oklahoma City: car bomb exploded outside federal office building, collapsing walls and floors. 168 persons were killed. Over 220 buildings sustained damage. Timothy McVeigh and Terry Nichols later convicted in the antigovernment plot to avenge the Branch Davidian standoff in Waco, TX.



are higher security risks. Certain stations may be perceived as less secure due to crowds or other factors. Similarly some routes may be perceived as less safe if they traverse areas that may be perceived as more likely to have security risks. For years international travel has been impacted by security concerns where persons would avoid certain airports or locations in their travel due to security concerns. For example, large hub airports may be avoided in favor of secondary hubs or direct flights. Certain bridges or tunnels may be avoided as in the case of individuals choosing to avoid using the Golden Gate bridge.

**Transportation System Performance** -- Perhaps the most obvious area of impact to transportation emanating from security concerns is the prospect that the performance of the transportation system will be altered as a result of the responses to security risks. These changes in transportation system performance will then impact travel behavior. The nature of the changes in performance covers the range of performance attributes.

For example, near-term impacts of September 11<sup>th</sup> include the suspension of many airline services, long delays for airport security, security enhancements for rail travel, and minor changes in auto parking. Other changes, all intended to enhance security, may impact the transportation of various products.

*How Can Security Impact Transportation System Performance?*

- *Cost to User*
- *Speed*
- *Accessibility*
- *Reliability*
- *Safety/Security*
- *Convenience*
- *Connectivity*

Of most interest to transportation planning efforts are the long-term impacts.

Security provisions will most probably result in higher user costs for some modes. Air travel costs are likely to increase as a result of airport security costs. The prospects that various modes will have to devote resources to security precautions may divert resources or in essence increase the cost of delivering services. Parking cost may increase if security initiatives and location constraints impact the available space for parking. Additional manpower will be required to provide the enhanced security, and the implementation of various technologies to inspect baggage and screen passengers will increase costs. To the extent that these costs are passed on to travelers, the comparative cost of air travel will increase and travel behavior may change. Other modes may also have higher costs as a result of security. This could include public modes and freight transport modes.

Travel speeds for various modes could also be impacted by security concerns. Specifically, security screening for public modes may impact the total trip time for those modes. In the case of air travel, there has been a significant increase in airport passenger servicing time in the near-term, and there is some prospect that some share of that extra time will be required even when the system fully adapts to new security standards. The high value of travel time for many air travelers will inevitably result in technology and staffing level adjustments to minimize the extra total trip time, however, that may be years in coming. Other travel time delays could be incurred for travel that involves structure parking with security, border crossings, and traveling to sensitive locations that have security restrictions.

Various modes could have changes in accessibility. For example, some parking facilities have closed sections in close proximity to buildings. Truck traffic has been restricted from certain locations and bridge, tunnel, and dam crossing travel may be eliminated or restricted. Access to and by sensitive facilities such as nuclear power plants may be more restricted, and no-fly

zones for such events as the Olympics and the Super Bowl are temporally impacting accessibility for some air travel. Modal reliability could also be impacted in situations where security incidents impact the on-time reliability of travel on various modes. Numerous incidents at airports have resulted in multi-hour shutdowns that have stopped air travel. Inspection delays for other modes may similarly impact travel time reliability. Over time, repeated occurrences will influence public perceptions about reliability and hence the attractiveness of the respective modes.

Safety and security is of concern to travelers, and, to the extent that the public perceives a change in relative security, they may change their travel behavior. This may include such actions as avoiding air travel, avoiding particular stations and terminals that are feared to be targets, avoiding routes with critical links that might be targets (bridges, tunnels etc.), and avoiding group travel. Convenience may be impacted in a number of ways. Enhanced security is certainly an inconvenience, as are luggage limitations and ticketing changes that, for example, require e-ticket receipts to access airport gate areas. Additional inconveniences may be caused by requirements for enhanced personal information sharing as a condition of receiving tickets for some modes. Parking location changes, restrictions on certain vehicles such as vans, and other changes may also inconvenience some travelers. Lack of vehicle access to certain locations or parking will inconvenience some travelers and licensure and vehicle registration requirements may become more burdensome. Security and convenience perceptions may alter some travel behaviors, particularly if they fall differentially across modes.

Finally, system connectivity could be impeded by security risk concerns. Over the past decade, a significant effort within the transportation planning community has focused on intermodalism for both personal and freight travel. The intention of intermodal connections is to enable easy transfer between modes and vehicles to facilitate the most convenient and cost effective use of various technologies for transport of people or freight to various locations. The focus of such planning has been to enable convenient unencumbered transfers. To the extent that security concerns require additional scrutiny of people or freight for various modes, then intermodal initiatives may be impeded by security concerns. For example, several states are considering high-speed rail networks that are being designed to have direct convenient access to airports. To the extent that direct connections require that all rail passenger undergo the same level of security review as airline passengers, then the concept of an integrated system requires the air travel security precautions to be applied to all rail travelers that would have access to the rail-air transfer station. Similarly, precautions for baggage handling would be required to meet the perhaps higher standards of airline baggage scrutiny. Airport security requirements could also impede the convenience envisioned with off-site airport baggage and passenger check in planned for some intermodal terminals. Similar issues could arise on the freight side where convenient intermodal transferring might require the security precautions of the most restrictive mode or product to be more broadly applied to insure security for intermodal connections.

**Investment Priorities** -- Speculation has centered on whether security risks will have an influence on public attitudes toward transportation investments. Some have suggested that the economic value of transportation is being recognized, and this will aid efforts to increase investment in transportation. Others anticipate a renewed interest in having transportation choices; specifically enhanced funding for rail modes. Still others worry that diversions of dollars to enhance security will detract from capacity improvements. The recent Bush administration proposal for the 2003 budget suggest at the aggregate level, overall national



priorities for enhanced security may put pressure on available transportation resources in the short term. Transportation investment priority changes could result from a number of considerations.

*Transportation Resource Pressures Resulting from Security Concerns*

- *Diversion of resources to security needs outside of transportation programs*
- *Diversion of funds to operating security enforcement/policing/planning/training*
- *Diversion of funds to capital investments in security (barriers, fencing, inspection, etc.)*
- *Use of funds to support network redundancy/connectivity*
- *Use of funds to support modal choice/redundancy*
- *Diversion of funds to design changes/enhancements to increase security*

Post September 11<sup>th</sup>, actions suggest a variety of possible investment needs as a result of increased sensitivity to security risks. These needs range from near-term initiatives to conduct strategic planning and assessments to supporting enhanced enforcement levels such as those found at airports, to longer-term needs to alter the physical characteristics of individual transportation investments and the system or network of investments. Changes could range from rerouting roadway alignments from sensitive sites to removing trash containers from rail station platforms. Enhancements to ITS technology as a tool to utilize in incident prevention and incident response have been contemplated, and simple design changes to enable additional vehicle inspection queues at border crossings or luggage and passenger scanning capacity at airports may be necessary. Revisiting the capability of our transportation network to handle special vehicles or military equipment in response to incidents or the exploration of modifications in our roadway network to more easily enable mass exodus from an urban area in response to a crisis are among the more complex and expensive strategies that might be pursued. Other major financial obligations could occur if decisions to change the connectivity or range of modal options in our transportation system were to move forward. Several interests, for example, have proposed major investments in high-speed rail in order to provide an alternative to dependency on air travel for longer distance trips. Additionally, certain travel behavior changes could result in different demands for transportation by various modes than are currently anticipated. This could result in changes in modal priorities, shifting geographic priorities, changes in project costs due to design or other security related changes, or other shifts in long-range transportation facility and service plans.

Having speculated on the possible repercussions of security risks to transportation and having attempted to organize those thoughts in something of a logical structure, the remainder of this paper focuses on more explicit consideration of how long range planning might change to accommodate explicit consideration of security risks.

## The Role of Security Risks in Long-Range Transportation Planning

Prior to September 11<sup>th</sup>, state DOTs thought of security issues as being operational, not planning, issues. Principal responsibility usually rested with law enforcement agencies. State DOT involvement was mostly in a support role in development of emergency response plans. Security issues were not an issue in most state and MPO surface transportation planning processes. Transportation Improvement Programs (TIPs) at the state and MPO levels did not contain allocations for security related issues. Agencies are now faced with determining how security concerns should be integrated into how we plan, design, implement and operate transportation facilities and services. Is security simply another goal for our transportation system that can be integrated into our planning similarly to how we accommodate safety concerns today, or does addressing security require more radical changes including such actions as redefining organizational structures, modifying basic planning processes and developing or refining planning methods, models and tools?

The goal of long-range statewide transportation planning is generally to lay out a long-range vision of the transportation system and its role in the overall economy and quality of life, specifically identifying priorities and goals that will drive subsequent decisions on investments. The long-range plan also often lays out the processes by which these visions are turned into specific implementable projects. Exactly how the long-range transportation planning process might be altered in light of security risks is explored in the context of the security risk definition noted previously.

Table 2 outlines examples of how security risks might be interpreted in terms of the role of a transportation agency and the implications on transportation planning. As noted in the table, the role of transportation agencies in reducing the probability of an incident attempt is relatively modest. Prudent sensitive actions of the agency can reduce the prospects of internal and customer incidents motivated by actions of the agency. There is very limited history of these types of incidents and no basis for assuming significant changes in the future. Prudent administration and appropriate training of employees to deal with potential problems is the best action and this is an operational issue whose impact on long-range planning will be non-existent or at most a modest shift in resources to administration from capital or operating categories.

The second area where transportation agencies may influence the presence of individuals who may be motivated to carryout terrorist actions is in their role as a regulator. Prudent controls on the licensing of individuals and in selected other regulatory areas may also limit the prospect that individuals who may cause terrorist attacks are around or able to do so. This regulatory responsibility could preclude individuals from entering the country or from having the mobility afforded by vehicle licenses. Again, prudent administration and appropriate training of employees to deal with potential problems is the best action. The impact on long-range planning will be non-existent or at most a modest shift in resources to administration from capital or operating categories.

Transportation agencies can play a larger role in influencing the vulnerability of transportation facilities to attack. Strategies can include limiting the information that can help in planning a successful and damaging attack, reducing the prospect for an internal attack, limiting the geographic access to sensitive locations/facilities, or providing security to reduce the prospect that someone could do something harmful in sensitive locations. Only certain aspects of these strategies would have implications on long-range planning efforts.

There could be implications to facility location, facility design, and operations of facilities and services.

The final category of potential involvement of transportation agencies is in the area of reducing the damage associated with an incident. There are two major areas of damage reduction that merit consideration. The first is limiting the personal and physical damage of the incident by limiting the severity of the impact. This might, for instance, include structural design changes to limit the prospect of an explosion causing serious damage. Other responses could include physical and locational design considerations that minimize the amount and nature of incidents. The second general area of damage mitigation refers to minimizing the subsequent personal and economic impact by having evacuation and service restoration strategies in place that can limit losses and restore functioning. Among the most expensive strategies that are being considered as actions to respond to terrorism are actions to increase the redundancy of the transportation system. Alternative modes or network connectivity strategies are primarily a tactic for post-incident restoration of system functioning. These strategies may reduce the impacts from an incident, particularly the economic impacts, however they do not impact the probability of such incidents.

### **Integrating Security Concerns into Long-Range Planning**

The discussions above address relationships among security risks and transportation agencies and transportation planning. They suggest how security concerns might be interjected into how transportation planning could be adapted to respond to security concerns but do not take the next step of specifically exploring how transportation planning professionals might go about changing what they do and how they do it in order to be more sensitive to security concerns. Are existing planning tools and models altered? Is the process amended to incorporate security? Is security another goal to add to the list along with subsequent objectives and performance measures? Can one simply screen all the jargon in plans and replace the term "safety" with "safety/security", or is there a distinct difference? Do security concerns merit changes in organizational charts, and how do the security responsibilities get spread across the federal, state, regional and local agencies involved in delivering transportation planning? Is security something that gets addressed in the public participation part of planning? How do the financial commitments to security initiatives get evaluated and how are tradeoffs made to reflect security concerns? And, is it premature to draw conclusions about how security impacts long-range planning?

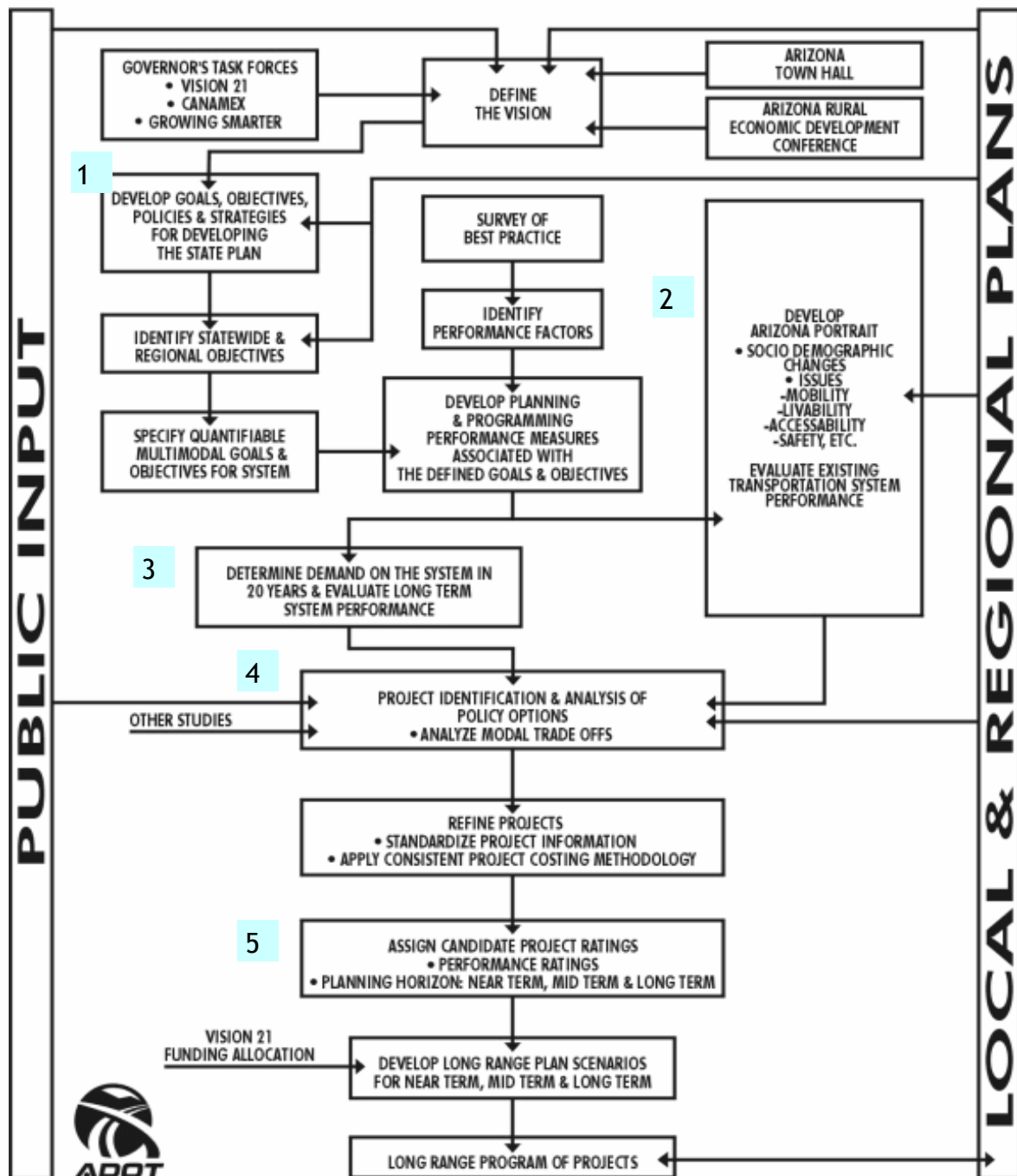
Figure 5 outlines the long range planning process for ADOT. In review of this figure, one can consider how security issues might be reflected in the proposed overall process. For purposes of discussion, five specific boxes in the figure have been identified as representative of classic process steps in long range planning. Each of these is discussed in terms of how security issues might be accommodated.

**Table 2 Responsibilities of Transportation Agencies in Influencing Security Risks**

<b>Security Risk Component</b>	<b>Possible Role of Transportation Agency</b>	<b>Implications for Transportation Planning</b>
<b>Probability of Incident Attempt</b>  Presence of individuals who have the motivation to plan and carryout acts of terrorism.	<ul style="list-style-type: none"> <li>Utilize regulatory and oversight capabilities to help identify/capture or exclude entry of possible terrorists (via licensing, border crossing enforcement, routine traffic enforcement, etc.).</li> <li>Carry out responsibilities in a manner that will minimize the prospect that employees, or affected parties (land owners, contractors, system users etc.) will be motivated to seek revenge through terrorism.</li> </ul>	<ul style="list-style-type: none"> <li>Enhance transportation agency capabilities in the areas of regulation and enforcement.</li> <li>Enhance customer interface capabilities of transportation workforce.</li> </ul>
<b>Vulnerability</b>  Prospect that a transportation target could be successfully terrorized	<ul style="list-style-type: none"> <li>Limit the information availability that might influence the choice of transportation as a terrorist target.</li> <li>Ensure the transportation workforce is screened and monitored to reduce likelihood of internal terrorism.</li> <li>Limit the access to sensitive targets.</li> <li>Secure critical elements in transportation system.</li> </ul>	<ul style="list-style-type: none"> <li>Evaluate Knowledge sharing/dissemination strategies.</li> <li>Upgrade employee and contractor screening and control capabilities.</li> <li>Explore physical and operational controls on access to sensitive locations.</li> <li>Reconsider alignment and service location criteria to include security concerns.</li> </ul>
<b>Damage</b>  The direct and indirect magnitude of the consequences in personal and economic terms	<ul style="list-style-type: none"> <li>Design systems and facilities so as to be resistant to attack.</li> <li>Have incident response capability to minimize loss of life and restore functioning of transportation system.</li> <li>Provide redundancies to enable system robustness after an incident.</li> </ul>	<ul style="list-style-type: none"> <li>Evaluate/modify system and facility design standards.</li> <li>Consider network robustness in project design and selection.</li> <li>Support investments to enable rapid incident response.</li> </ul>

Figure 5

# DRAFT PROCESS FOR **LONG RANGE STATE PLAN**



1. Goal Development - Clearly the reemphasized interest in security merits incorporation as a goal of the transportation system. Security will be a prominent goal for all types of transportation planning and operations just as safety is the single most noted goal for transportation today.

#### **Simplified Planning Process Steps**

1. Goal Development
2. Conditions Assessment
3. Needs Assessment
4. Project Identification
5. Project Programming

- With the incorporation of the security goal will come the need to develop specific objectives, criteria and performance measures that reflect security concerns. It may be logical to structure these goals along the lines of the security risk calculation by focusing on minimizing each factor: incident attempts, vulnerability of system, and damage resistance of infrastructure and services. Various other approaches for defining security objectives and performance measures may also be logical in the context of the overall strategy for objective development.
2. Conditions Assessment - Just as planning benefits from a rich understanding of current conditions, so to it will be important to have a data base that can identify the current conditions as it relates to security. This might include enrichments to various databases that would specifically address relevant considerations such as vulnerability. Many of the system inventory data items may have traits appended that address security considerations. Items may include such things as share of facilities that are secured, proximity to sensitive sites, critical links or susceptible structures (tunnels, bridges, etc.). Information on volumes/units of hazardous materials by route may be compiled and the roles of various facilities in evacuation may be compiled. The status of employee and contractor security efforts may be itemized and initiatives to secure transportation information may be itemized. Other summaries of security relative to established security performance standards may also be itemized in the conditions assessment.
  3. Needs Assessment - The needs assessment process determines how current trends and forecasts influence the performance of the transportation system for the design year of the plan. In this step of the process the planner would have to forecast future travel behavior and as such would need to incorporate evidence or forecasts of changes in travel behavior as a result of security concerns. If there were evidence of changes in trip generation, mode choice, trip distribution or trip assignment as a result of security concerns, these changes could result in different needs assessment findings than might otherwise be the case. These changes could be direct, for example fears of flying resulting in lower airline travel, or indirect, for example slower and more expensive air travel and thus greater use of alternatives. The needs assessment process requires forecasts of conditions twenty years in the future and hence it is difficult to extrapolate or deduce the impacts from security based on the relatively modest level of information available to date. Obviously, the magnitude of the impacts is very dependent on the prospect of future incidents and the public response. Even the consequence of security initiatives is difficult to determine at this point in time as technology and procedure changes will be refined and their consequences in terms of time and cost for various types of travel remain to be seen. Close monitoring of the

consequences of security initiatives is certainly appropriate in order to develop a database on changes in system performance and traveler response. This response is not limited to individual travelers. As or more important is its influence on freight and commercial traffic.

4. **Project Identification** - The project identification step is the essence of planning in that it uses the knowledge of needs and the knowledge of possible solutions to come up with specific proposed solutions to particular needs. This step involves the creative energies of planners in conceiving specific plans. The design and location of transportation solutions may be affected by security concerns. For example, alignments may be altered to avoid sensitive locations and aspects of the design may be modified to reduce the prospect of or damage from an incident. In the case of statewide planning the actual plan development may be occurring at the local or regional levels and are assembled into statewide plans at the state level. Other projects may be developed specifically to respond to security concerns. These may be initiatives to secure existing facilities, modify designs to minimize damage, or enhance incident response.
5. **Project Selection** - The final element in traditional planning is the selection of projects to be part of an overall program of actions. In this step, the projects that best respond to the collective goal set are chosen for implementation. The decision-makers will have to find ways to evaluate the relative merits of various project proposals in light of the set of goals. The importance of security in the context of other priorities such as safety and capacity will need to be determined. This resource programming activity forces tradeoffs and implicitly requires judgments or quantification of the value of security investments. At the state level, priorities can be dramatically influenced by federal mandates or requirements. Local public and political pressures may also influence project selections. In the case of security initiatives federal mandates may significantly influence decision-making. It remains to be seen how the general public rates security investments in the context of real tradeoffs between other projects or new revenues.

As the discussion above indicates, security concerns will influence how each of the five traditional steps in long-range planning is carried out. Similarly, security considerations will impact short- and mid-range planning, operations and maintenance activities, research agendas, and regulatory and administrative aspects of the operations of state departments of transportation. A significant share of the influence will be determined by federal guidance and input by enforcement agencies; the magnitude of the response to security concerns is only partially in the hands of state transportation officials.

### **General Observations on Security Planning**

The response of transportation agencies to security concerns will encompass all aspects of agency operations from day to day operations and administration to midterm planning to long-range planning. Security assessments and enhancements for operating facilities will impact current operations the greatest. Beyond the near term the largest influence on long-range planning is likely to be the impact on resource availability. The available resources influence the long-range program of transportation investment and diversions of funds to

support near-term security initiatives may have a significant impact on long-range planning initiatives.

### **The State of Knowledge and Uncertainty**

The memories of the incidents of September 11<sup>th</sup> are very fresh, yet the country has a very limited history of terrorism incidents that can form a meaningful knowledge base. This knowledge base is being supplemented with international experience and scenario development such as explored in Table 1. Nonetheless, there is far from a consensus on the various tactics and priorities for reducing security risks. Although it is important that energies be invested in understanding the security risks in our transportation systems and responding with prevention and response capabilities where evident, there are other aspects of security preparedness or prevention that have huge implications in terms of resource commitments that may not be prudent based on current knowledge levels. For example, some of the transportation initiatives being proposed are actions intended to provide a contingency transportation capability in response to a transportation terrorism attack. Network redundancy or alternative modes can help do that but these are very high cost options that do not reduce the prospects of an incident or minimize the probability of loss of life, only facilitate a return to normality after an incident. It may be premature to program these extremely expensive responses as other, not yet detailed or identified responses may be more effective and efficient. Terminology like “the war on terrorism” and the freshness of the memories of September 11<sup>th</sup> encourage a tendency to do everything possible to reduce security risks. Resource constraints, both financial and other, will quickly require a more selective strategy.

In the immediate aftermath of a tragedy there is also a temptation to do things that one is knowledgeable about or able to do. The transportation industry, with knowledge in areas such as disaster response and network design, is tempted to apply existing solutions to these new problems. Although these tools and tactics will have a place in a comprehensive response to terrorism, developing a rich understanding of the role of transportation in terrorism and careful and systematic evaluation of various responses is likely to offer the most rational long-term response. The emotions inherent in dealing with a subject of this type are understandable; however, just as the transportation community has developed measured and data based responses to transportation safety problems, so too is it necessary to develop the information and expertise base that will enable a response to terrorism in appropriate and effective ways. Clearly, this speaks to a need to invest in learning, research, and information collection at this point in time while simultaneously increasing security in areas where it is obviously necessary and possible.

### **Defining Roles**

Perhaps the best parallel to security planning for transportation agencies is the experience in planning for emergency preparedness and incident management. Terrorists’ threats and incidents are an example of an emergency of the type that transportation agencies in concert with law enforcement, the private sector, and other agencies have experienced. These types of initiatives require coordination across functional and jurisdictional lines and as such are



communications and process intensive activities. The agencies have very different cultures and perspectives and, thus, resource, turf and ego issues will inevitably evolve. Reiterating the critical shared mission and utilizing the lessons learned in prior collaboration intensive initiatives will be necessary. The diversity of involvement is well exemplified by looking at the diversity of ownership of transportation infrastructure. The roadway system has broad-based ownership and this is compounded by the private sector ownership of vehicles and terminal facilities.

September 11<sup>th</sup> reiterated the importance of coordination and communication among the many different operating agencies in a region and across the nation in response to an incident. Such

coordination is needed to allow enforcement/security/safety responses to occur in an expeditious manner, while at the same time still permitting the transportation system to handle the possibly overwhelming public response to the incident. Although coordination and communication are critical to facilitate responses in a crisis mode, coordination and communication in planning for security is important to insure effective and efficient security risk investments. Security responses are also challenging some state officials who are being asked to make major short-term investment commitments that challenge TIP and NEPA approval processes. Cross-agency coordination and communications also will be necessary to insure rule modifications and expedited approvals where necessary.

### Priority Setting and Tradeoffs

The security risk equation provides a helpful way to think about how security risk can be minimized. Transportation planners have opportunities to influence each of the factors that contribute to the overall security risk. Careful analysis of how each possible action might influence the overall security risk will be a helpful strategy in insuring that resources are

$$\text{Security Risk} = \text{Probability of Incident Attempt} \times \text{Vulnerability} \times \text{Damage}$$

directed in the most appropriate direction. Transportation agencies regularly make these types of rather complex and somewhat subjective tradeoffs for safety investments where options include near-term operating costs for enforcement, mid-term opportunities for education initiatives and maintenance activities, as well as longer-term investments in facility and vehicle design. Similar multifaceted tradeoffs will be required to prioritize security

#### Arizona Roadway Ownership (Center Lane Miles, 2000)

Under Federal Control	11,926
Bureau of Indian Affairs/Tribal	7,725
US Forest Service	3,065
National Park Service	562
US Fish & Wildlife	557
Other Federal Agencies	17
Under State Control	6,611
Under Local Control	36,657
Counties (15)	19,158
Municipalities	17,499

Source: ADOT CY 2000 HPMS data submittal to FHWA.

resources both among competing security investments and between security goals and other transportation goals such as safety.

As immediate and near-term efforts focus on operational spending to reduce vulnerability, the most immediate planning challenge will be determining which, if any, significant longer-term capital investments to make to enhance security. Defining how various investments contribute to security such that their contribution can be evaluated and tradeoff decisions made will be the most challenging aspect of post September 11<sup>th</sup> planning. Expert judgment and multiagency collaboration will be required as agencies throughout the country work to develop experience in security investment evaluation.

### **Specific Security Issues in Arizona**

Although many issues involving security are common across agencies and geography, each state and locality will also have unique conditions that will influence both the security risks that they face and the institutional context in which they do security planning and adapt transportation planning to incorporate security concerns. One element of uniqueness can be the nature of unique or specific threats that an area may face. Some of these items are addressed below.

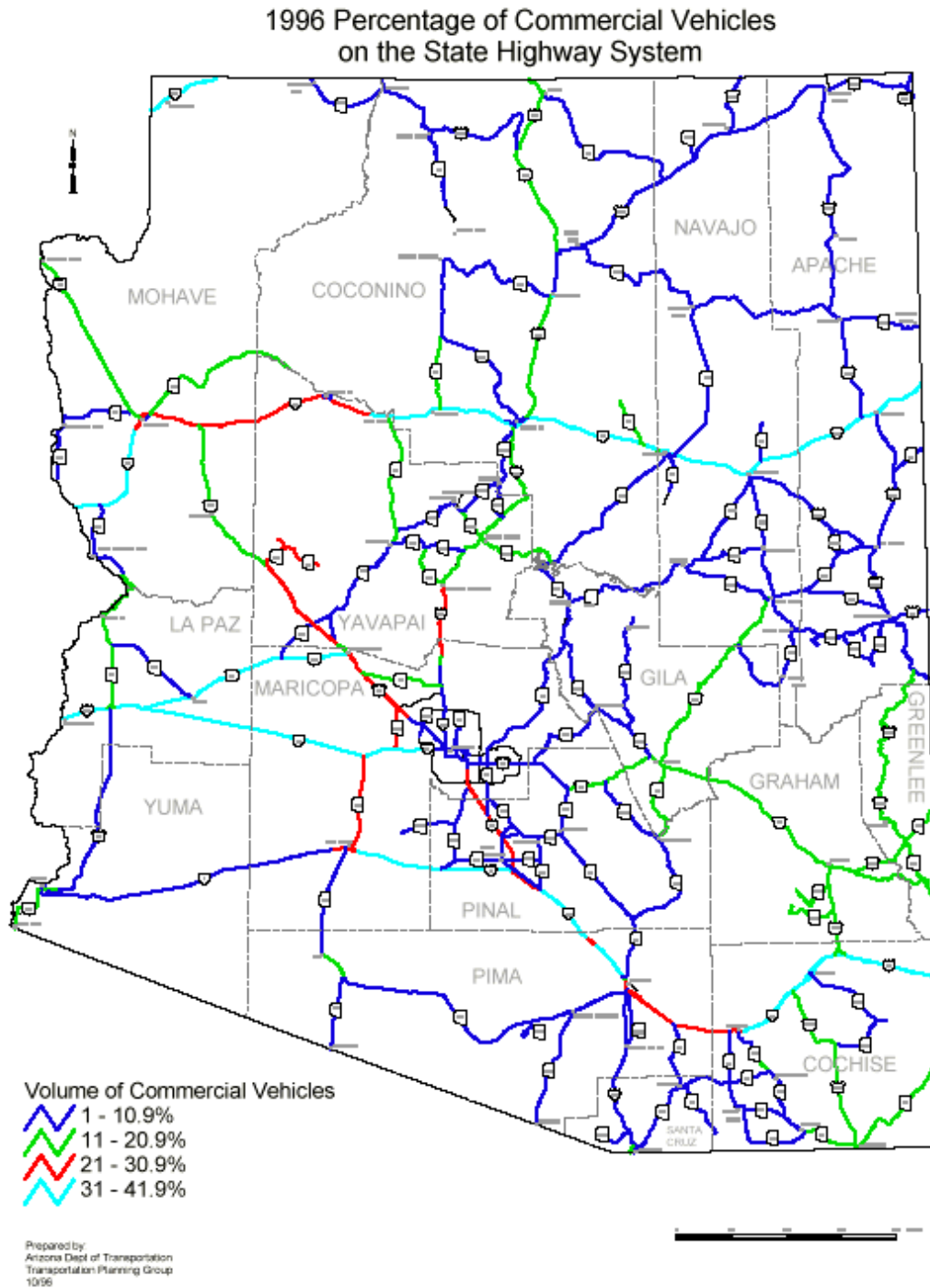
#### **Critical Network Segments and High Profile Targets**

One element of transportation security involves identifying areas that would be probable targets based on the prospect that an incident in that location could have a significant impact. Locations where the damage to people or property would be greatest may be high profile target locations that merit consideration for precautions or other initiatives to minimize the impacts of an incident. Several traits might be considered in identifying critical segments. Specific roadway links that are vulnerable or, if damaged, could cause expensive and prolonged disruptions in accessibility are examples of critical network segments. Bridges, tunnels or other critical links such as roadways over the Hoover Dam might be deemed critical links. The circuitry introduced if such a facility were out of service might be a consideration as might cost to repair or replace.

Other critical network segments might be defined based on the presence of alternative mode or path access to specific locations. For example, access to military facilities, nuclear facilities and other critical locations might increase the motivation for redundancy in access opportunities. The prospect of a federal nuclear waste material depository in neighboring Nevada may result in significant volumes of nuclear waste materials crossing through Arizona. This might be perceived as a possible terrorist target.

Finally, critical links might be defined based on the nature of the traffic flow and the opportunities this presents for terrorist opportunities. Routes with hazardous materials, routes with significant commercial traffic or military materials movements might be such routes. Figure 6 shows the shares of commercial traffic on Arizona roads. This might be one factor in evaluating security risks.

Figure 6 Arizona Commercial Vehicle Traffic



## **Borders**

Arizona has an international border and as such is involved in border security. Borders present opportunities to monitor transportation activities and hence provide an opportunity to help insure that illegal materials of the type that might be used in a terrorist incident are precluded from entering the country. Similarly, persons crossing the border can be scrutinized to attempt to exclude illegal entry of persons that might be intent on causing harm.

## **Conclusions**

Although it may be too early to begin changing our long-range infrastructure plans in response to security risks, it is apparent that there will be changes in spending priorities in the near term and most probably over a longer period of time. Over the next several years, security considerations will result in changes in how transportation is planned, designed, implemented and operated. Transportation goals, planning processes, databases, analytical tools, decision-making considerations, and organizational structures will change due to security concerns. Transportation will be on the front line in responding to security risks. The response to security concerns will cross jurisdictional and functional lines and be among the most complex and important challenges to transportation professionals.

It will be important for transportation planners to monitor closely changes in travel behavior and try to fully understand their underlying causes. This will help planners assess the potential for longer-term shifts in behavior as a result of security-induced changes. Similarly, planners should closely monitor the performance of our transportation systems with regard to time and cost factors as well as security, so as to be able to make informed extrapolations of how these system and service changes might be impacting travel behavior. It will be important to take steps to ensure that the September 11<sup>th</sup> tragedy does not slow our progress toward a true multimodal transportation system. Nor should these events serve to further polarize modal prejudices or be used as an emotional springboard to advocate investments whose merits should be scrutinized with clear thinking. Initiatives should be put in place to monitor how September 11<sup>th</sup> and subsequent security concerns actually change U.S. travel behavior and transportation needs.

As transportation planners have struggled to find adequate resources to fully fund capacity and safety goals, a major challenge of security concerns will be ensuring that the immediate emergency diversion of time and resources does not hinder the long-term capabilities of transportation planners to respond to transportation needs. Public recognition of the cost of providing enhanced security and public support for additional funding if transportation resources are diverted to security investments may be required to ensure that the price of security is not a rapid decline in the condition and performance of our existing transportation system.

In the meantime, transportation operating agencies will be busy providing near-term responses to security concerns. The transportation planning profession has a significant knowledge base and capability in various areas such as incident response, hazardous materials transportation, and disaster response and recovery that provide a strong springboard for providing enhanced security and incident response. Transportation planning has grown over the past several decades to encompass far more than providing cost-effective, safe transportation capacity. Transportation has embraced a broader goal set including social and

environmental factors. Thus, transportation planners are knowledgeable in integrating additional considerations into the goal set for planning transportation facilities and services. As experts in dealing with travel safety concerns, transportation professionals have an understanding of how complex tradeoffs between short- and long-term and capital and operating/enforcement decisions can be made. The new challenge will be applying the lessons learned in developing these capabilities to incorporating security considerations into the long-range planning process.

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# **Trends and Developments Shaping Transportation's Future**

# **TRENDS AND DEVELOPMENTS SHAPING TRANSPORTATION'S FUTURE**

**Robert L. Olson**

Research Director

Institute for Alternative Futures

## **INTRODUCTION**

This white paper reports on trends and emerging developments that are relevant to transportation planning in Arizona. Many of the ideas presented here are future-oriented or are related to larger trends in technology and society, and so may not have previously come to the attention of the state's transportation planners.

Some of the trends and forecasts explored in this paper, such as future developments in intelligent transportation systems, are comparatively certain. It is possible to look at the research and testing underway today to see what is likely to be available tomorrow. Other topics, like the time frame in which global oil production will begin to decline, are inherently more uncertain and controversial. Still other topics, like the proliferation of Segways, a new kind of personal transportation device, are included as part of a deliberate look at "wildcards" – developments that may not be likely, but that would have very large consequences if they should occur. Exploring this whole range of emerging developments can help Arizona's transportation planners work with a broader understanding of the possibilities ahead. Your view of the future and its possibilities influences your actions today, and your actions today shape the future.



The paper explores trends and developments within six broad topic areas or themes:

❑ **New Ways of Thinking About the Future in Transportation Planning**

- Understanding the larger context of decisions
- Clarifying aspirations for the future and setting goals

❑ **Energy-Related Developments**

- Rising oil and gasoline prices
- High fuel efficiency IC vehicles and hybrids
- Potential evolution toward a hydrogen economy
- Implications for combined power-transportation infrastructure
- Implications for auto usage, congestion and air quality

❑ **Converging Developments Affecting Urbanization Patterns**

- Examples of unanticipated problems
- Outlines of an emerging vision

❑ **Communication-Related Developments**

- Computer power and network capacity
- Communication substitutions for travel
- Communication inducements for travel
- Intelligent vehicles and transportation systems

❑ **Demographic and Societal Trends**

- Population
- Population and Water
- Aging and Health
- Boomer Retirement Lifestyle Preferences
- Demands for Transparency

❑ **Wildcards**

- Near-term oil price increases
- Rapid rollout of the Segway
- Near term water shortages limit development
- A shift from SUVs to Hypercars

## **THEME 1: NEW WAYS OF THINKING ABOUT THE FUTURE IN TRANSPORTATION PLANNING**

The most difficult public policy decisions are those that relate to strategic choices that have long-term impacts on society. Among all the strategic choices that a state like Arizona makes, capital budgeting decisions for transportation arguably have the most far-reaching impacts. They shape the direction and character of urban development and are literally “set in concrete,” influencing the future for generations.

Transportation planning has often seemed more sophisticated than other areas of capital budgeting, with decision-making supported by computer-based demand projection models. Unfortunately, much of this apparent sophistication was illusory. A good case can be made that transportation planning was at its worst in decades past when planners were most confident of their quantitative methodologies. Now the problems they face are much more difficult, but the planning itself is improving thanks to less quantitative but more comprehensive ways of thinking about the future.

These more comprehensive ways of thinking about the future, being used in today's most sophisticated planning efforts in both corporations and government, involve: 1) striving to see the larger context of decisions, the driving forces of change, alternative possibilities, and the key uncertainties ahead, and 2) involving relevant stakeholders in clarifying their aspirations for the preferred future and setting goals for creating that future.<sup>i</sup> Both of these trends are already influencing transportation planning and are likely to affect it much more over the generation ahead.

## **Understanding the Larger Context of Decisions**

Transportation planning has always projected trends into the future. What has been missing is not so much a long-range perspective as “peripheral vision” – a sustained effort to understand the larger context of what transportation decisions really affect.

This means, above all, striving to understand the connections between transportation choices and other concerns such as shaping land use and urban development patterns, reducing urban air pollution, avoiding unsustainable long-term costs of infrastructure maintenance, improving access to housing and jobs for lower income people and people living in poverty, minimizing the fragmentation of ecosystems and damage to environmentally sensitive areas, and maintaining or restoring the kind of human scale in the built environment that fosters a sense of local community. It also means looking at all forms of transportation, the intermodal connections between them, and other means of facilitating “access” such as mixed use development and pedestrian mobility.

The challenge is to keep working over time (not just the current planning cycle) to improve understanding of this larger context, to collaborate with people who have other kinds of expertise needed to build this understanding, and to be honest about uncertainties. Techniques like scenario development can be used to construct images of how this larger context could change over time and communicate them to the public and decision makers, highlighting rather than hiding the uncertainties and the alternative theories of how the future could unfold.<sup>ii</sup>

## **Clarifying Aspirations for the Preferred Future and Setting Goals**

Rather than being reactive – responding only to immediate pressures, or extrapolating trends and developing plans to accommodate them – more

sophisticated planning efforts operate from the perspective that the future is something we proactively create. This does not mean that existing trends and circumstances can be ignored and that anything is possible. It does mean that the future is more open to shaping than we often assume, and that we tend to underestimate what is possible, especially over years or decades of effort.

A more proactive approach to planning implies that we need to clarify our aspirations for the preferred future, the kind of future we want to create. There is no way to do this in the transportation field except to open the debates and negotiations that were once held only among a small circle of transportation experts to environmental activists, community leaders, appointed members of metropolitan planning organizations, and the general public, who bring in all kinds of conflicting views. The ISTEA process has helped open transportation planning to these kinds of inputs, but much more needs to be done to foster real dialogue and meaningful collective learning that allows participants to reach greater agreement about the character of the long-term preferred future.

This approach involves a fundamental change from traditional planning. Instead of moving incrementally from the present into the future, it calls for understanding the broad context of change, clarifying aspirations, and then positing a “best feasible” preferred future and working backward toward the present to develop goals, strategies and actions for creating that future.

## **THEME 2: ENERGY-RELATED DEVELOPMENTS**

Transportation is based on energy consuming technologies, primarily technologies that use oil. Cars and light trucks are oil’s main users and its dominant growth market. As a result, changes in the price and availability of oil could have major impacts on transportation. Conversely, improvements in transportation technology can improve energy productivity and reduce the effects

of fossil fuel combustion on human health and the environment. Important changes in oil prices and availability and in transportation technology are likely over the next two decades.

### **Rising Oil and Gasoline Prices**

The price of gasoline was at or near all-time lows during the 1990s. But the surge in energy prices during 2000 and most of 2001 has drawn attention once again to the availability and security of energy resources and the prospects for both supplies and prices.

The most influential work on forecasting the availability of oil was done by petroleum geologist M. King Hubbert at the Shell research lab in Houston.<sup>iii</sup> In 1956, Hubbert calculated that U.S. oil production would follow a logistic curve, peaking in the early 1970s and then declining just as rapidly as it had grown. Most industry experts understandably rejected Hubbert's analysis, despite his highly respected status. It was news no one wanted to hear, and several forecasters had cried "wolf" before and been proved wrong. The controversy over Hubbert's analysis raged until 1970, when U.S. crude production peaked and began to fall, making the U.S. increasingly dependent on imports.

Beginning in 1995, several analysts began to apply Hubbert's methodology to world oil production, producing sobering estimates. The analysis that caused the greatest stir within the global oil industry was done by an organization known for its optimistic outlook, the influential, Paris-based International Energy Agency (IEA), and reported in the IEA's 1998 *World Energy Outlook*. The energy projections contained in previous editions of the World Energy Outlook had a time horizon of 2010. The 1998 edition extended the projection horizon from 2010 until 2020 and applied a Hubbert-type analysis using a generous United States Geological Service estimate of 2300 Bb for the world Ultimate. The analysis projected that non-OPEC conventional oil production will peak in the

early '00s and that total world production will peak during the period 2010-2020. This was a startling conclusion at the time and was published only after months of recalculation and internal debate.<sup>iv</sup>

Nearing the top of the so-called “global Hubbert’s peak” does not mean the world is running out of oil. But it does mean that prices will inevitably go up. This price rise is likely to begin during the 00s as non-OPEC production peaks and then declines, giving growing leverage over prices to nations in the Persian Gulf where two-thirds of the world’s petroleum reserves are located. Third World economic development will continue to drive the growth of demand. Once the global production peak is passed, both developed and developing nations will be bidding against each other for the dwindling oil supply, driving prices higher until substitutes are sufficiently developed to reduce oil demand.

### **High Fuel Efficiency IC Vehicles and Hybrids**

Recent transportation projections for OECD regions conclude that, absent major price increases or policy actions, further strong increases in transportation energy demand and CO<sub>2</sub> emissions can be expected out to 2010. After 2010 a stabilization and then eventually a reduction in transportation energy demand is possible as more energy-efficient transportation technologies take an increasing market share.<sup>v</sup> Three transportation modes account for the vast majority of energy consumption: cars, trucks, and aviation. Modal shifts toward more energy-intensive modes for freight, including a projected tripling of air freight volume by 2020, mean that the largest opportunities for reducing oil consumption and CO<sub>2</sub> emissions are through technical improvements in cars and light trucks.

There is considerable room for improvement: new American cars average only 24 mpg, a 20-year low. In Europe, where gasoline prices are higher and smaller cars dominate the market, many models with conventional internal combustion engines get in the vicinity of 40 mpg. Volkswagen has recently begun selling

Europeans a 78-mpg, four-seat non-hybrid subcompact and plans an ultra-light two-seat city car for 2003 that will get 235 mpg (not a typo).

In the U.S., where small cars have a small market, fuel-electric hybrid technology will be the key to reducing oil consumption. The 48 mpg Toyota Prius, the 64-mpg Honda Insight, and the new Honda Civic hybrid are proving highly popular. Ford, Daimler-Chrysler, and General Motors all plan to begin selling Hybrid SUVs in 2003, and all three are already testing mid-sized family sedans in the range of 60 mpg to 80 mpg. Ford's chairman estimates that up to 20 percent of cars on the road by 2010 could be hybrid fuel-electric.

### **Potential Evolution Toward a Hydrogen Economy**

The most important emerging development in road vehicle technology is the dramatic progress underway in the design and manufacturing of fuel cells. Fuel cells convert hydrogen into electricity by an electrochemical process that is highly efficient and totally nonpolluting. They can run on any hydrocarbon fuel, using a reformer to extract the hydrogen. Progress in fuel cell technology is occurring much faster than anticipated a few years ago because automobile manufacturers, under continuing pressure to lower emissions, and anticipating the coming global decline in oil production, have collectively poured over \$2 billion into fuel cell research and development. It appears likely, therefore, that fuel-electric hybrids will be a transitional technology on the road to electric drive vehicles powered by fuel cells.

As per current plans, BMW, Daimler-Chrysler, Ford, GM, Toyota and Honda will all introduce fuel cell-powered cars by 2004-2005, but these initial vehicles will still be too expensive to be popular. Meanwhile, fuel cell growth is expected to occur much faster in the distributed power generation market. Every doubling of cumulative production volume is anticipated to make fuel cells 10 to 30 percent cheaper, so they are likely to gain substantial market share in buildings of all

kinds over the decade ahead. As production volume grows, falling prices will make widespread fuel cell use in vehicles affordable. Like other states, Arizona will need to consider steps it could take, such as fleet purchasing and partnerships with businesses, to help accelerate the shift to fuel cells. How fast this shift can occur is not yet fully clear. General Motors has announced the aim of having 10 percent of its new cars fuel cell powered by 2010.

Because of fuel cell progress, the concept of a “hydrogen economy” has recently caught the imagination of many industrial leaders. Top management at Royal Dutch Shell and BP say they are committed to bringing a hydrogen economy into existence. William Ford wants to preside over Ford’s complete transition from internal combustion engines to electric drives powered by hydrogen fuel cells. The Bush administration has launched the Freedom Car initiative to support industry’s development of fuel cell vehicles and increased the DOE budget for hydrogen and fuel cells. The November 2001 issue of Fortune magazine ran a feature article on “The Coming Hydrogen Economy” – a sure sign that the concept is entering the mainstream.

Not that a hydrogen economy is a sure thing. There are major questions and challenges ahead about the how best to produce hydrogen, how to make it available to consumers, and what pathways of infrastructure investment could take us to a hydrogen economy most quickly, safely and efficiently. Most hydrogen will initially be produced by steam reforming of natural gas, but there are many other options including extracting hydrogen from coal with carbon sequestration and thermal cracking or electrolysis to extract hydrogen from water using nuclear energy. The “holy grail” for many researchers in the field is a solar hydrogen economy based on biological hydrogen production, wind, photovoltaics, and other renewable sources. A major problem of solar electric technologies is their intermittency – they only produce power when the sun is shining. Conversion to hydrogen as a storage medium and energy carrier offers a solution.



## **Implications for Combined Power-Transportation Infrastructure**

Some experts believe that the interaction between fuel cell-based power generation and vehicle markets could be the key to moving toward a hydrogen economy much more quickly than anyone thought possible a few years ago. Here is one example of how it might happen.

As production volume increases and costs come down, fuel cells will become more common in buildings of all kinds, including homes. At least a dozen North American companies are racing to create a new market for residential fuel cells that run on hydrogen extracted from natural gas. General Motors itself has announced plans to bring out a fuel cell power-generation product; Ballard in Canada, which has been heavily supported by Daimler-Chrysler, is working to bring out units for residential use; and Plug Power in Latham, NY has partnered with General Electric and will begin shipping the GE HomeGen 7000 in 2003. It might be possible, therefore, for some people to begin using hydrogen even before a hydrogen refueling infrastructure has been developed by “gassing up” their fuel cell cars at home, getting hydrogen from the natural gas reformers that feed their home fuel cells.

As national standards for connecting micropower technologies to the electric grid come into place, people could also begin to use their fuel cell cars as generators. Each new fuel cell-powered car will in effect be a ~20+kW<sub>e</sub> power plant on wheels. The average American car is parked about 96 percent of the time, usually in habitual places. Imagine driving your car to work and leaving it in a parking structure where you plug it in to the electric grid—not to recharge, as battery powered electric cars require, but to serve as a generating asset. While you work, your car is part of the “virtual power plant” feeding electricity back into the grid, and you are being credited for this electricity production at the real-time price, which is highest in the daytime. While you go about your life, your car is busy repaying a significant part of its own purchase price or lease fee by selling

power to the grid. This arrangement would make fuel cell cars a great deal, causing sales to boom and creating the demand that can justify rapid construction of a major hydrogen infrastructure in which hydrogen is produced and delivered in many other ways.<sup>vi</sup>

### **Implications for Auto Usage, Congestion and Air Quality**

The implications of these energy-related developments are difficult to assess. On the one hand, the prospect of rising prices means that over the generation ahead we may come within sight of inflection points in important transportation trends such as rising transportation energy consumption, constant growth in vehicle miles traveled, and the shift toward larger cars, SUVs, and light trucks. If the energy costs of transportation go high enough, they could put economic constraints on low-density development.

On the other hand, hybrid fuel-electric vehicles with high fuel efficiency might blunt the impact of gasoline price increases, allowing VMT to continue rising, and allowing Americans to maintain their love affair with big cars without incurring big costs. Fuel cell powered vehicles may allow us to maintain our high levels of auto use despite a drop in world oil production. Even if higher energy prices drive a shift to smaller “green cars,” we may find ourselves suffering through worsening “green traffic jams.” What actually happens will depend greatly on the timing of price changes and technology developments. The most disruptive impacts would occur if significant price increases occur before the end of the ‘00s, before hybrid vehicles have taken a significant market share.

One certainty is that the technical changes we can see coming today will make possible major improvements in air quality. The Toyota Prius hybrid cuts fuel consumption by nearly 50 percent from the similarly sized Corolla, but it cuts emissions by 90 percent. Fuel cells will cut emissions still further. Fuel cells running directly on hydrogen will have no emissions at all except for water vapor.

By mid-century, one of the transportation-related complaints in Phoenix and Tucson may be that cars are increasing the humidity, worsening the temperature-humidity index.

### **THEME 3: CONVERGING DEVELOPMENTS AFFECTING URBANIZATION PATTERNS**

Since World War II, our nation's urban development has been guided by a dominant vision of how metropolitan areas should grow. It is commonly described as suburbanization, low-density development, or urban sprawl. This urbanization pattern made an attractive way of life available for millions of people. It offered home ownership, modern schools, responsive local government, and an uncrowded environment of clean air and green lawns. It offered unprecedented mobility based on widespread automobile ownership and a rapidly expanding system of interstate highways and urban expressways. There is no question that this post-war development pattern contributed to an unprecedented surge of economic growth that brought the majority of our nation's population into the middle class. It literally became a part of the "American dream."

However, pursuing this development pattern over the past fifty years has given rise to **unanticipated problems**. At first they seemed to be manageable "side effects" of growth, but now they loom as serious threats to our nation's long-term well being. At the same time, **new visions** of how metropolitan areas should grow are emerging.

#### **Examples of Unanticipated Problems**

*Infrastructure Maintenance Costs* – Costs for maintaining the far-flung highway, water, and sewage infrastructure systems needed to support low-density

development are soaring in many parts of the country, making it increasingly difficult to finance new construction. This problem will continue to escalate as the infrastructures age. While infrastructure to support new development on urban fringes is becoming more expensive to build and maintain over the long run, we continue to leave underutilized infrastructure behind and build on the fringe because the short-term costs of doing so are low for both businesses and home buyers. Short-term incentive structures are leading us into a future where our children and grandchildren could face potentially crippling costs.

*Congestion* – Peak hour traffic congestion is worsening, especially in the suburbs, exacting an economic toll in lost time and worker productivity. Each year, Americans lose 2 billion hours to gridlock, and road jams are responsible for business losses of \$40 billion. Longer commutes make it more difficult for people to get to where new jobs are, leading to higher labor costs. Congestion effects economic development by making areas less desirable for potential employees and customers.

*Housing* – Areas of low-density development provide little low- or even moderate-income housing. As a result, low-income people are often concentrated in the cheapest, most deteriorating housing within urban areas. Often they are without automobiles or adequate transit links to reach the areas where new jobs are being created. This concentration of poverty and isolation from jobs is a major contributor to unemployment, crime, school breakdown and other social problems.

*Environment* – A recent study within the U.S. Environmental Protection Agency highlighted the problem that current development patterns are fragmenting ecosystems into patches too small and isolated to maintain species diversity. Low-density development is also encroaching on environmentally sensitive areas, eliminating open space and causing a permanent loss of prime agricultural land. Travel in single occupancy vehicles is the greatest contributor to urban air

pollution and the single largest factor in the buildup of greenhouse gases in the atmosphere.

*Security* – High oil consumption, over half of which is used by automobiles, makes the U.S. vulnerable to cutoffs by foreign suppliers and makes oil imports the biggest item in our foreign trade deficit.

*Community* – Our society is going through a profound disintegration of local community life. One of the important developments weakening our sense of community is the loss of human scale in the physical environment as development is geared more toward automobiles, roads and parking than toward walkable communities where neighbors can meet and interact.

### **Outlines of an Emerging Vision**

A new vision of how metropolitan areas should grow is emerging. Its outlines are visible in the heavy overlap between emerging movements of thought and policy such as *smart growth*, the *new urbanism*, *transit-oriented development*, *traditional neighborhood development*, *livable communities*, and *community sustainability*. Ideas being promoted by these movements are becoming increasingly influential, but it is not at all clear whether these ideas provide a workable alternative direction or whether they will become sufficiently accepted and influential to overturn public policies favoring the interests that benefit from current growth patterns.

These overlapping movements of thought all see the examples of unanticipated problems listed above not as separate, individual problems but rather as a “syndrome” of interconnected problems all generated simultaneously by our pursuit of low-density development. In this view, the only way to solve these interconnected problems is to invent new patterns of urban development superior to urban sprawl.

The general character of the new approach being proposed is a deliberate shift away from today's sprawl development pattern toward more compact, clustered, community-centered development patterns. Automobiles would still be the dominant means of transportation for a long period of time as this new development pattern evolved, and would always remain important, but eventually people would become less dependent on them. Expanded transit systems would connect centers of development with each other and with the older urban area. These centers of development would have many features of the traditional neighborhood designs that make older European cities and America's small towns so appealing. Many jobs and stores and a substantial amount of housing would be located within walking distance of transit stops. Neighborhoods would be designed to maximize the ease of pedestrian and bicycle movement. There would be wider choices of housing types, densities, and costs than in conventional suburbs, with affordable housing in relatively close proximity to lower- and middle-income jobs. Public plazas, squares, and greens would be designed to encourage the presence of people throughout the day and evening. Natural features like creeks and streams would be restored where feasible, with the most dramatic features highlighted in public settings. All development clusters would have well-defined centers with public buildings and distinctive architectural features to create a unique "sense of place." Each cluster of communities would have a defined edge such as a wildlife corridor or agricultural greenbelt permanently protected from development.<sup>vii</sup>

Not surprisingly, people with this kind of vision of the preferred future tend to share a harsh critique of much of transportation policy and planning, which they see as a principal driver of the urban sprawl that is the opposite of what they want.

*Induced Traffic and Latent Demand* – Their basic critique is that building more highways and widening roads to ease traffic congestion always acts to spur more development and induce more traffic. Increasing road capacity makes longer

commutes easier, so people are willing to live farther and farther from their places of work. But as growing numbers of people choose to live further out, the longer commutes grow as congested as the shorter commutes used to be and commuting times grow ever longer. Then additional lanes or highways are added to relieve congestion and the cycle of *induced traffic* repeats itself, with low-density development spreading over more and more of the landscape. If there is always more *latent demand* than can be met, then we will never be able to build our way out of traffic congestion, and the real constraint on driving is always going to be traffic. In this view, a fundamental reconsideration of transportation planning theory is called for that focuses on the broader question of “what do we want our urban areas to be like?” and is open to the radical notion of actually using congestion as a force for limiting automobile trips.<sup>viii</sup>

*Automobile Subsidies* – A related argument is that people have been willing to sit for longer and longer periods of time in bumper-to-bumper traffic largely because automobile use is to a significant extent what economists call a “free good,” and demand always goes through the roof for free goods. Government subsidies for highways and parking alone have been estimated to amount to between 8 and 10 percent of the U.S. GNP. Local government services to motorists and truckers – traffic engineering, traffic control, police traffic patrolling, street repair, and maintenance – are also all free goods. Each year on U.S. roads, 6 million crashes occur; 41,000 people are killed and more than 3 million injured - this at the cost of \$150 billion. “Softer” costs such as the health costs of urban air pollution could also be added. Everyone, not just drivers, pays these costs.<sup>ix</sup>

*Urban Design* – The fundamental question of “what do we want our urban areas to be like?” is the touchstone to which proponents of “smart growth,” the “new urbanism” and related movements always return. They believe transportation planning has consistently led us in wrong directions. For example, the architects Andres Duany and Elizabeth Plater-Zybek argue that Norman Bel Geddes, the visionary behind the U.S. Interstate system, was right when he declared in 1939

that “Motorways must not be allowed to infringe upon the city.” Bel Geddes wanted the kind of highway development that has occurred more commonly in Western Europe, where roadside development is not permitted on highways passing through the countryside, and where highways providing access to urban areas must take on the low-speed geometries of avenues and boulevards. In the U.S., the exact opposite has become more common. Highways are typically lined with commercial strips and have often been routed through the centers of cities, splitting downtowns and cutting neighborhoods into pieces. Duany and Plater-Zyberk argue that nearly every aspect of urban design that supports a thriving pedestrian life, safer streets, a strong sense of community, aesthetic beauty, and easy access to nature has been shut out by a preoccupation with engineering criteria for achieving unimpeded flows of traffic.<sup>x</sup>

The emerging vision of a potentially superior pattern of urban development is certainly attractive in some respects, but many questions remain about its social, economic, and political desirability and feasibility. In any case, a change in this direction cannot be quick or easy. Today’s dominant vision of low-density development is deeply embedded in our mindsets, institutional arrangements, policies, regulations, and investments in existing infrastructure.

Nevertheless, if the unanticipated problems reviewed above continue to worsen, and if this emerging vision continues to be refined and to gain adherents, then over the coming generation transportation agencies will go through the greatest change since the post-war development of modern transportation planning.



## **THEME 4: COMMUNICATION-RELATED DEVELOPMENTS**

### **Computer Power and Network Capacity**

Computers and communications are increasingly central to the future of transportation. To use European terms, progress in “telematics” will influence transportation demand and “informatize” all transportation-related technologies. The rate of progress in telematics will therefore emerge as an important factor in transportation planning.

At the level of basic capabilities, progress in information technology is almost certain to continue for over a decade at rates far greater than people expect. Moore’s Law, the observation of Intel co-founder Gordon Moore that the processing power of integrated circuit chips doubles roughly every 18 months, is expected to continue for at least a decade until the limits of the optical lithography used in manufacturing chips begin to be approached. Developments in molecular computing or quantum computing might keep Moore’s Law going into the foreseeable future, but that is not yet a sure bet. What is sure, however, is that a doubling of processing power every 18 months will take us to barely imaginable levels of computing power within a decade. When chips were evolving from containing 10 transistors to 20 to 40 to 80, and so on, the impacts of doublings were modest. But the most advanced chip designs today contain nearly 10 million transistors. Before the limits of optical lithography are reached it should be possible to put over a billion transistors on a chip.

The rates at which information can be sent over a single strand of optical fiber have increased even faster than Moore’s Law. The rate of progress toward both fixed and wireless high capacity broadband networks is limited far more by investment levels and uncertainties about future demand than by technology. It seems reasonable to say, therefore, that there is probably no telematics

application in transportation that will be blocked over the next 20 years by lack of computing or communication capacities.

### **Communication Substitutions for Travel**

Facing frightening forecasts of worsening congestion, transportation planners are understandably interested in the possibility that telecommunication can substitute for travel. Areas where this kind of substitution seems feasible include:

- ✓ Telecommuting, using telecommunications to replace commuting between home and work
- ✓ Online shopping, banking, entertainment, and health services that allow consumers to obtain the services they desire without leaving home
- ✓ Distance learning and other interactive educational services that make formal learning possible from home or work
- ✓ Web portals for obtaining government services and carrying out routine activities like licensing and income tax filing
- ✓ Just-in-time manufacturing systems that avoid wasteful shipping and reduce dependence on large inventories
- ✓ Broadcasting of a wider variety of live events, combined with the spread of wide screen high resolution television, so that more people watch the events from home
- ✓ Dedicated telecommunications applications that expand traveler ridesharing or that save trips by consolidating freight loads

Substitutions such as these clearly have had some effect already and will have more effect in the future, but unfortunately there is no evidence to date that the effect is very significant.

## Communication Inducements for Travel

The evidence of the last few decades suggests, to the contrary, that telecommunications and travel grow together, feeding on each other.<sup>xi</sup> Due to latent demand, other travelers quickly take any road space vacated by telecommuters and others utilizing communications instead of travel. At the same time, telecommunications appear to induce travel through a variety of casual routes:<sup>xii</sup>

- ✓ Telecommunication spurs productivity improvements and income growth, and people with more income tend to travel more
- ✓ Improvements in communication expand the number and geographic scope of the business and social relationships in which people engage
- ✓ Telecommunication supports the geographical decentralization of organizational functions and residential settlement, which tends to move trip origins and destinations further apart
- ✓ The use of wireless mobile phones, Palm Pilots, Blackberries and similar devices is reducing reluctance to travel by making travel time more productive
- ✓ Telecommunication is supporting population growth and economic activity in rural communities, causing growth in rural travel
- ✓ Telecommunication is enabling the rise of businesses that specialize in customized vehicle trips, from home pizza delivery and overnight package delivery to temporary employment services

The spread of higher bandwidth, more interactive communications will allow easier and more effective substitutions of communications for travel, but it will also increase all the inducements for travel listed above. As a result, there is no reason to anticipate that telecommunications will have any significant impact on reducing congestion over the generation ahead. However, if an oil crisis should occur, or if a significant rise in energy prices causes major increases in transportation costs, we might be surprised as a society by how much our rapidly evolving telecommunications systems can substitute for travel, when needed.

## Intelligent Vehicles and Transportation Systems

At the same time that fuel-electric hybrids and fuel cell vehicles begin coming into the marketplace in large numbers later in this decade, a wide range of **intelligent vehicle technologies** will also be appearing. These two lines of development are likely to synergize, creating a public perception that a new era of high tech is emerging in transportation. Several of the expected developments are listed below. A few of these have already begun to appear as expensive options on Lexus, Mercedes-Benz, and Infiniti models.

- ✓ 42-volt power systems
- ✓ X-by-wire technology replacing all the hydraulic and mechanical systems in the vehicle with electronic sensors and motors
- ✓ Vehicle self-diagnostic systems that analyze the status of the vehicle and communicate results to the driver; more advanced systems will communicate status information to a control center when appropriate, which can analyze the data, predict malfunctions in real time, inform the driver, and schedule the service required
- ✓ Radar-based collision warning systems that gauge the speed and distance of oncoming traffic, alert drivers to danger, and induce braking in emergencies
- ✓ Emergency alert systems that alert the driver when a car drifts from its lane; more advanced systems will track driver's eyelid movements and sound an alarm if a driver is becoming too sleepy to drive safely
- ✓ Vision-enhancement screens on the windshield to reduce glare from the halo effect of approaching lights; more advanced systems will offer fighter-jet-style night-vision-equipped windshields
- ✓ Built-in mobile communications technology for wireless voice and data communication and serving as a basis for other telematic applications
- ✓ Global Positioning System (GPS) technology for navigation, vehicle location in the event of breakdowns or accidents, or locating a stolen vehicle

- ✓ Navigation technology based on GPS and detailed digital map databases
- ✓ Real time traffic congestion information as a value-added component to the digital mapping and navigation service
- ✓ Further into the future, “Intelligent Windshields” will display context-aware information and services, highlighting signs related to the driver’s chosen route, highlighting obstacles ahead or pedestrians to watch for, and alerting drivers to points of interest. When parked, the windshield can serve as a kiosk presenting information about its surroundings or upcoming events, or as a movie/video display screen (possible by 2020)
- ✓ Still further in the future, vehicles may continuously talk to each other electronically to provide real-time, fully accurate traffic information
- ✓ This kind of inter-vehicle communication is likely to be the basis for automatic highway systems with computer controlled vehicles running in high-speed, close-spaced platoons – if this vision of the future is ever realized. The paradigm of centralized computer control of vehicles is likely to be replaced by a distributed paradigm that integrates fast computers and high performance networks through novel computer algorithms. This vision of the future may not materialize, however, due to the extraordinary demands it places on vehicle reliability and the potential for massive accident liability.

Most of these emerging capabilities will become available in the marketplace, but there is considerable uncertainty about what features will eventually become “standard” and what consumers will be willing to pay for. Higher accident rates among today’s cell phone users highlights a potential problem of drivers being distracted by in-vehicle telematic systems. A growing area of “human factors” research is emerging to study this problem and find ways to avoid it.

**Intelligent Transportation Systems (ITS)** are a broader set of applications that include intelligent vehicle capabilities but also include a larger infrastructure of diverse technologies for information processing, communications, and control. ITS may become much more important than is currently appreciated, because it appears to be developing in the direction of a “super infrastructure.” Existing infrastructures for information, security, banking, medical systems, and other areas are generally stand-alone systems that work independently of each other.

ITS systems are driving toward an integrating infrastructure that will allow these different functions to interact. A “super infrastructure” will make new integrated services possible and cut costs by eliminating duplicated functions, but it could also increase vulnerability.

To see how ITS may spur infrastructure integration, imagine an advanced truck passing through a highway ETC gate 25 years from now.

*By wireless communication, the toll gate identifies the truck, identifies the bank the trucking firm uses, accesses the bank computer, and draws the toll fee from the appropriate bank account. The toll gate also reports the truck's location to the company that is waiting for its contents to be delivered, estimating arrival time based on current and projected traffic conditions. It performs a security check to insure that the electronic seals on the truck's cargo have not been broken. If the truck's biomonitoring system indicates that the driver has become dangerously sleepy, the toll gate will shunt the driver to a temporary rest area.*

Many ITS applications are already coming into place. Applications likely to be adopted or become more widespread over the generation ahead include the following:

#### *Advanced Traffic Management Systems (ATMS)*

- ✓ Traffic signal coordination
- ✓ Freeway ramp meter signals for access management
- ✓ Changeable message signs to warn drivers of upcoming road closures, accidents, and other hazards
- ✓ Congestion detection systems evolving from closed circuit TV to GIS applications to intercommunicating vehicles as traffic probes
- ✓ Route diversion systems

### *Advanced Traveler Information Systems (ATIS)*

- ✓ 511 systems that consolidate and expand phone access to travel information
- ✓ Traveler information via public kiosks, Internet web sites, radio broadcast, cable TV, etc.
- ✓ Dynamic message signs
- ✓ Smart call boxes
- ✓ In-vehicle navigation and information systems
- ✓ Weather information systems

### *Advanced Public Transportation Systems*

- ✓ Electronic payment (VISA/MC/debt cards) of transit fares
- ✓ Automatic vehicle location (AVL) technology to track buses, provide up to the minute information on transit schedule and arrival times, reroute buses to avoid congestion, route paratransit flexibly and efficiently, and improve response time in case of accident
- ✓ Traveler information kiosks with real time information on transit schedules, arrival times, and intermodal connections

### *Advanced Rural Transportation Systems (ARTS)*

- ✓ Hazardous weather warnings
- ✓ Animal warning systems
- ✓ Motorist emergency services including in vehicle Mayday devices
- ✓ Statewide software architectures that integrate operations and maintenance functions with information on road closings, weather, tourism and traffic

### *Commercial Vehicle Operation (CVO)*

- ✓ Commercial vehicle applications of all intelligent vehicle systems
- ✓ Electronic credential checking
- ✓ Weigh-in-motion
- ✓ In vehicle self-inspection systems to assess cargo stability and security
- ✓ Smart inspections, such as performance-based brake testing devices
- ✓ E-seals and other electronic cargo security systems
- ✓ Smart gateways to automate vehicle, driver and cargo identification and clearance at port and terminal gates
- ✓ Smart truckways to optimize truck routing to reduce conflict with passenger traffic and manage truck travel through congested or high-risk areas
- ✓ Onboard office work via wireless Internet access, voice recognition, and other tools
- ✓ Virtual road signs to alert drivers to upcoming hazards, low-clearance bridges, curved ramps, steep downgrades, intersections with limited turning radii, etc.
- ✓ Load matching systems to optimize truck utilization, minimize empty haulbacks
- ✓ Intermodal hazmat management systems to track the flow of hazmat containers and cargo across modes, improve the routing of vehicles carrying hazardous materials, and facilitate rapid emergency response

## **THEME 5: DEMOGRAPHIC AND SOCIETAL TRENDS**

### **Population**

Population growth, population aging, and the growth of minorities are the most important demographic trends in Arizona that need to be considered in



transportation planning. Arizona's population grew by 40% between 1990 and 2000, reaching a total population of over 5 million. The state's population is projected to continue growing rapidly, reaching over 7 million by 2020, 10 million by 2040, and nearly 12 million by mid-century. However the possibility of worsening water scarcity may begin to slow growth during the latter part of this period (see below).

Despite its reputation as a retirement haven, Arizona's current population is actually slightly younger than the national average. But the most rapidly growing age cohort in Arizona is the 85 and over population, which grew by 82 percent over the past decade. The other, much larger, age cohort that grew most rapidly was people aged 45 to 54 (up 80 percent). That larger cohort will become the elderly population in 2020.

Arizona's other most distinctive demographic trait is the growth of minorities. Between 1990 and 2000, the state's Hispanic population increased by 57 percent to over 1 million, accounting for 22.7 percent of the total population. Arizona now has the sixth largest Hispanic population among all the states. American Indians are the state's second largest minority group, with a 1999 estimate of approximately 261,000. Arizona has the third largest number of American Indians among all 50 states, and since 1990 has led the nation in the numerical growth of its Native American population. Asians account for only a little over 2 percent of Arizona's population, but they are the fastest growing minority, up over 75 percent since 1990. Arizona's relatively small Black population grew by over 50 percent to about 175,000. Minorities now compose 36.2 percent of Arizona's total population. If current demographic trends continue, by mid-century Arizona could have a "minority majority."

## **Population and Water**

Settlement patterns depend more than anything else on transportation patterns, but in Arizona and other parts of the West there is a possibility that water will become the ultimate determinant of development as urban areas outrun their water supplies. The limits of water availability are already being reached in smaller Arizona towns like Pine and Strawberry. Throughout rural parts of the state, where it is too costly to build more canals to bring in water from the Colorado River, more and more people are tapping into smaller and smaller supplies of groundwater. Wells are going deeper, and then going dry, forcing people to truck water in.

The state's biggest cities, Phoenix and Tucson, have abundant water supplies thanks to the 2.8 million acre feet of Colorado River water annually allocated to Arizona and transported via the Central Arizona Project. However continuing development is projected to fully tap the Central Arizona Project's water by 2030. Further growth would depend on expensive and speculative undertakings such as desalinizing seawater. After 2030, therefore, water scarcity may emerge as a significant constraint on growth.

## **Aging and Health**

By 2030, more than one in five Arizonan's will be over 65. As the state's population lives longer and the proportion of the population over 65 grows, the number of people who will be limited by chronic conditions and disabilities will also grow. This will place increasing demands on state governments, especially on medical and social services, but also on transportation systems. Losing the independence and mobility that the automobile makes possible is one of the most heart-breaking stages of old age. Flexible and affordable transportation services that can come to people's homes and take them to their destinations will be in growing demand. Unlike younger people who need to travel quickly and on

schedule, older people can often tolerate slower service and more restricted service times. What matters most is simply that they retain the ability to travel.

One of the most important conclusions to emerge strongly from recent research on aging is that healthy lifestyles are more influential than genetic factors in helping older people avoid the physical deterioration traditionally associated with aging. People who maintain a proper weight, eat a healthy diet, remain physically active, do not use tobacco, and practice other healthy behaviors have half the rate of disability of those who do not practice healthy behaviors. Over the decades ahead, a growing proportion of the elderly population is likely to practice *healthy aging*, staying active and mobile longer than has been common in the past.

This healthy aging population will make growing demands for sidewalks and street arrangements that are safe for walking and bicycling. They will continue driving longer and can benefit from conscious efforts to improve the visibility of signage, road edges, and lane separations. “Intelligent vehicle” technologies such as emergency alert systems, collision warning systems, and vision-enhancing windshield screens can do much to help elderly people drive safely.

A simple change that can help avoid fatal collisions involving older drivers is to improve vision screening tests for driver’s license renewal. Elderly deaths from car crashes are 12 percent higher in states that do not require vision screening tests, according to a study by Dr. Melvin Shipp, a professor at the University of Alabama’s School of Optometry.<sup>xiii</sup> Dr. Shipp studied traffic fatality records from 1989 to 1991 in 48 states. Night vision declines steadily with age, and peripheral vision is reduced, affecting the ability to see other vehicles and pedestrians approaching from the side. State mandated vision tests prompt older drivers to visit their eye doctors to update the prescriptions on their corrective lenses prior to renewing their license. A thorough eye exam can identify the small number of

older drivers whose vision has reached a stage where they are likely to be a hazard to themselves and others.

## **Boomer Retirement Lifestyle Preferences**

The individualistic, idealistic, demanding Baby Boom generation has continually transformed institutions and expectations as this large population group has moved through elementary school, college, birthing and parenthood, and midlife careers. Now the oldest Boomers are beginning to prepare for retirement, and it looks like they will remain true to form, transforming the life stage of retirement. Phyllis Moen, a professor of sociology at Cornell, is conducting the largest study to date of Boomer retirement lifestyle preferences.<sup>xiv</sup> The study's preliminary findings suggest that there is a fundamental shift in how Baby Boomers view retirement. Moen says that "Communities, workplaces and society will have to accommodate to aging Baby Boomers who will move into retirement healthier, better educated and more energetic than any previous generation and who don't want their father's retirement."

About one-third of the Boomers surveyed are planning to keep on working. Others are looking for ways to cut back significantly on work while still continuing, part-time, to do the work they like best. About a third are considering more formal education. Two-thirds consider traveling and volunteering as important. Many view retirement as a chance to do things more in keeping with their ideas and ideals than they were able to do in full time jobs. Moen concludes that, "Many workers of this generation do not view retirement as the end of work but rather as a change in work and lifestyle, a time to do what you like and consider important rather than what you have to do."

The healthy, educated, active Boomer retirees of the generation ahead seem likely to generate many more trips than the more relaxed retirees of the generation just passed. They are less likely to be satisfied living in Sun City-type

environments or suburbs distant from centers of activity. As driving becomes more difficult for many of them, they are likely to become strong advocates for improving transit services. The kind of neighborhoods advocated by proponents of the New Urbanism – traditional neighborhood designs centered on transit stations that connect out to the larger urban area – is likely to be one of the kinds of living arrangements most appealing to aging, empty nest Boomers.

### **Demands for Transparency**

Transportation agencies, like other government operations and business activities, are likely to face growing pressures for greater *transparency* – for operating in an open and accountable manner and providing the public with information it can use to evaluate an organization's performance. Today's headlines are filled with stories that reflect this growing pressure, from Enron and Arthur Anderson to the FBI.

The growing demands for transparency are broad-ranging. The strongest demands are for information related to the bottom line – economic performance. The pressure for greater transparency comes primarily from the marketplace itself. Financial markets can only function well when investors have the information they need to make judgments about who will most productively make use of their capital. The more the economy is in flux due to rapid technological change, globalization and other forces, the more investors need good information. The greatest nightmare for investors is that corporations they are invested in may be hiding losses or covering up activities that if revealed could cause a major drop in stock value.

Demands for transparency are also increasing for the “new bottom lines” of environmental and social responsibility. Home Depot, the world's largest lumber company, recently committed itself to stop purchasing lumber from endangered forests. The decision was largely the result of an e-mail, Internet, and mass

media campaign that involved Internet coordination among hundreds of environmental organizations and grassroots groups around the world. In the late 1990s, when information circulated on the Internet showing that Nike produced some of its athletic shoes under unhealthy and exploitive working conditions, first CNN and then media outlets around the world picked up the story. The company quickly instituted sweeping reforms to protect its brand value from permanent damage.

As the pressure for external transparency grows, organizations will inevitably be pushed to be more transparent internally. Secrecy and distrust within bureaucracies sabotage efforts to motivate and empower employees and have them operate with a common purpose.

Transportation agencies influence the allocation of large amounts of money. They deal with a topic that really matters to citizens. Their decisions have major impacts not just on mobility but on the larger character of urban development. They have close relationships to political leaders and to private sector contractors. All of these conditions will make them increasingly vulnerable to criticism as pressures for greater transparency continue to build in our society. The best protection is to take the initiative internally to operate in an increasingly open and accountable manner.

## **THEME 6: WILDCARDS**

“Wildcards” are developments that are not currently viewed as likely, but that would have very large consequences if they should occur. Several of the potential developments listed below are actually highly likely in the long run, but would be surprising if they occurred in the decade ahead.

## **Near Term Oil Price Increases**

Two potential developments could lead to large energy price increases in the '00s, with highly disruptive effects on transportation. The first is a significant cutback of oil available from the Middle East as a result of war, coordinated efforts to use the “oil weapon” to influence U.S. policy toward Israel, terrorism, or other disruptions. The probability of such developments is impossible to estimate, but it is clearly not zero.

The second development is a sooner-than-expected peaking and decline of global crude production. Several recent analysis have estimated that the peak year for world oil production could be as soon as 2004 to 2008, after which oil availability would begin to decline and prices would rapidly rise. These analyses are controversial, but they have been published in major peer-reviewed sources such as *Nature*, *Science* and *Scientific American*.<sup>xv</sup> None of our political leaders have paid attention to these forecasts, so there has been no acceleration of the kind of actions that might mitigate the impacts.

A peaking of global production this early would be a truly disruptive wildcard. While energy efficiency and alternative energy sources could allow a smooth transition away from oil over the decades ahead, there is no way they could be brought into place fast enough to deal with a global production decline beginning in the '00s. The result would be rapidly raising oil prices with global economic disarray and particularly severe impacts on mobility and agriculture.

## **Rapid Rollout of the Segway**

During 2001 the media gave a huge advertising boost to the thing called “It” being developed by Dean Kamen, a multimillionaire engineering legend with more than 150 patents. Amazon’s Jeff Bezos and other high tech industry leaders invested in It and touted it as a more important development than the

personal computer or the Internet. As the time for revealing what It is grew near, some insiders got more specific and said it was the most revolutionary transportation invention since the automobile.

When It, now called the “Segway,” was unveiled at the start of 2002, it turned out to be a two-wheeled personal transportation device about the size of a lawn mower, powered by a battery and stabilized by gyroscopes and 10 computers that keep it balanced. The rider stands on a platform over its single axle and holds on to handlebars that steer the device, leaning forward to accelerate up to 12.5 mph and leaning back to brake.

Segways are not on the market yet, but are being tested by the military, the Postal Service, the Atlanta police force, and General Electric – and winning enthusiastic fans. Most observers see the Segway as a high tech toy that will never have more than a small niche market. Kamen believes it’s a wildcard that will happen, revolutionizing urban transportation.

Kamen has already spent nearly a million dollars lobbying legislatures, and 20 states have passed laws approving the use of Segways on public sidewalks. Nineteen other states are scheduled to consider the issue before the end of 2002. The Senate Committee on Environment and Public Works has approved on a voice vote a measure that allows the Segway to be used on all sidewalks and bike paths built with federal funds, as long as local authorities agree.

Segways would be most likely to become popular in states like Arizona where bad weather would seldom inhibit their use. They might be especially popular with aging baby boomers and retirees who could regain youthful mobility through the use of these “Human Transporters” (the other more formal name for the device). It is worthwhile considering what would happen if Segways catch on.



They weigh 69 to 95 pounds, depending on the model, and can carry up to 325 pounds (rider plus cargo). With that much mass, and traveling at 12 mph, some of the collisions that occur on sidewalks are sure to cause serious injuries. As more injuries occur, citizens and consumer groups will increasingly challenge the use of Segways on sidewalks, arguing that if bicycles, motor scooters, and rollerblades are not permitted on sidewalks in many cities, Segways should be banned as well. This might create unprecedented pressures for changes in urban design and transportation engineering toward more construction of bikeways and road lanes reserved for bicycles and Segways. In some areas, widespread Segway use might actually reduce traffic congestion.

### **Near Term Water Shortages Limit Development**

Water issues are nothing new in Arizona, but there are a number of wildcard possibilities that could bring water limits on development into play earlier than expected. Water shortages in adjoining states might lead to renewed water conflicts that unhinge existing allocation agreements. The “death of the Gulf” might emerge as a major political and environmental issue as the lack of fresh water inflow and overfishing devastate the ecology of the Gulf of California. El Nino-driven drought and growing impacts of global warming might reduce water flows in the Colorado.

Developments like these may not be likely, but they are possible. In any case, it may not be too soon to think about what more “water-efficient settlement patterns” may need to be like, and to consider whether current transportation planning is encouraging or discouraging such patterns.

### **A Shift From SUVs to Hypercars**

Americans love their big cars – over half of passenger car sales last year were for gas-guzzling SUVs, minivans, and light trucks. Barring dramatic gas price

increases, it seems highly unlikely that small economy cars will make a comeback. But there is a wildcard possibility that by the end of the decade the new rage will be big cars that get 70-100 miles per gallon. There is no doubt that vehicles like this are possible. They are a wildcard because a wide range of engineering improvements would need to be made by an industry not known for rapid innovation.

In 2000, Hypercar Incorporated, a firm spun off from the Rocky Mountain Institute in Colorado, designed a super-efficient cost-competitive, midsize-SUV concept car able to get the equivalent of 99 mpg. It can drive 330 miles on 7.5 pounds of compressed hydrogen. The car's body is made of ultralight carbon-fiber composite, which can absorb up to five times more crash energy per pound than steel. The body is mounted on a chassis platform that contains fuel cells, hydrogen tanks, the brake system, and a score of computers and auxiliary electronics. Electricity from the fuel cells drives electric motors mounted within all four wheels. Moving at 55 mph, the Hypercar uses no more power than a normal SUV needs just for its air conditioner.

GM's new AUTOnomy fuel cell-electric concept car draws on many of the ideas pioneered by Hypercar. A chassis platform GM's designers refer to as the "skateboard" is made of advanced composite material and houses all the drivetrain essentials and electronics. Bodies of various kinds, from 2-seater sports cars to SUVs, can be mated to the skateboard. The mating is both physical – with mechanical locks – and electronic, with the upper body connecting to the platform much like a laptop docks into a docking station. Like the Hypercar design, the AUTOnomy combines steering, acceleration and braking in a drive-by-wire system with a vertical handle that the driver grips.

AUTOnomy represents GM's vision of how automobiles will be designed and built in 2020, so it would be surprising – but not impossible – to see vehicles like

this on the road in the '00s. When they do appear, and reach a competitive price point, they are likely to be extremely popular.

## CONCLUSION

There are four quite different lines of thinking that can be used to explore the policy implications the developments reviewed here may have for Arizona.

The first approach, which applies to comparatively likely developments, is to ask ***“How do we need to respond?”*** For example, it is virtually certain that Arizona’s population will continue to grow older and that older people will drive more than they did in the past. Appropriate responses include measures such as improving the visibility of signage, road edges and lane separations and mandating better vision screening tests for drivers’ license renewal.

A second approach, which applies to areas of greater uncertainty, is to ask ***“What are the most ‘robust’ policies or actions that make sense across a variety of future conditions?”*** For example, taking full advantage of emerging Advanced Traffic Management Systems and Advanced Public Transportation Systems will be essential if future traffic congestion is on the high side of the range of forecasts. But these actions make sense under almost any foreseeable conditions.

A third approach, which often applies in the areas of greatest controversy, is to ask ***“Do we need to seriously question our basic assumptions about this issue?”*** This is always difficult to do, impossible for some people who have been involved in a field for a long time. The critique of conventional transportation planning being put forward by smart growth advocates, the New Urbanism and others poses this question in a striking way. For Phoenix, in particular, it may be important to reexamine traditional assumptions and draw on ideas from the

emerging alternative vision of how metropolitan areas should grow and how transportation choices can steer growth into new patterns.

The fourth approach is to focus on the *preferred future* and ask “**What do we want the future to be like and how do we create it?**” And then act to drive change rather than adapt to it. The recent actions of the California legislature to require cuts in the tailpipe emissions of greenhouse gases by cars and light trucks is a dramatic example of this approach, where California is literally challenging the federal government for the lead in setting environmental and transportation policy in the United States. If the California action holds against court challenges, it will accelerate the shifts described here to hybrid fuel-electric and then fuel cell-electric vehicles.

Applying these four questions to the developments reviewed here, as well as other topics, is an excellent methodology for making transportation strategies more creative and responsive. This kind of thinking can be done individually, but often works best in interactive facilitated workshop settings.

Adopting new ways of thinking about the future can help take transportation planning to a higher level where decisions are made with an understanding of their larger context, a wider range of possible futures are examined, and transportation choices are made with greater attention to their role in shaping a desirable future.

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<sup>i</sup> Institute for Alternative Futures, *Environmental Scanning Methods*, presentation to the seminar on Government Foresight at the Brookings Institution, May 2002.

<sup>ii</sup> Thomas W. Bonnett and Robert L. Olson, “How Scenarios Enrich Public Policy Decisions” in *Learning From the Future*, Liam Fahey and Robert M. Randall, eds. (New York: John Wiley & Sons, 2000), pp. 308-324.

<sup>iii</sup> Kenneth S. Deffeyes, *Hubbert’s Peak* (Princeton, NJ: Princeton University Press), 2001.

<sup>iv</sup> International Energy Agency, *World Energy Outlook 1998* (Paris: IEA), 1998.

<sup>v</sup> Michael Landwehr and Celine Marie-Lilliu, *Transportation Projections in OECD Regions – Detailed Report* (Paris: IEA), May 2002.

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